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Future Naval Training Environments

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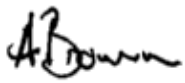

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Executive summary

In July 2001, the Secretary of the Navy asked the Center for Naval Analyses to evaluate alternative methods for training naval forces after the Vieques Island, Puerto Rico training range closes in May 2003, and also to evaluate long-term naval force training options for ensuring that future naval forces are well prepared for real-world operations.

We approached this task by organizing a Senior Study Group composed of retired, senior military officers and former Defense officials to provide an operational and policy perspective to the training options, and an Analysis Team to evaluate training requirements and alternatives. Admiral Leighton Smith, USN, retired, and General Charles Wilhelm, USMC, retired, co-chaired the Senior Study Group. Dr. Alan Brown led the Analysis Team. Members of the Senior Study Group and the Analysis Team are named on the cover of this Report. In general, the findings of the Analysis Team are consistent with the operational experience and intuition of the Senior Study Group. This report summarizes the results of the analysis and the key findings of the Study Group. The conclusions of the Senior Study Group are described in full in an appendix.

In carrying out our tasks, we examined the combat training environments of all military services. We evaluated critical aspects of Navy and Marine training, including training methods for key warfare areas, and range support needs. We attempted to predict needs for future training environments, including the use of simulations in such environments.

We evaluated two very important concepts that are part of combat training: emotional conditioning—the process of conditioning individuals to perform their functions in circumstances of great personal danger; and lethal responsibility—the training of the people who make decisions that result immediately in lethal outcomes. We

identified for each naval warfare area the people (jobs) responsible for such lethal decisions and the training they require.

Finally, we looked specifically at the implications of closing the Vieques range.

Conclusions

Real fire and maneuver ranges are essential

The Department of the Navy is responsible for ensuring that its units are manned at appropriate levels, and that people assigned to those units are trained and equipped to succeed in their missions in a variety of potential combat environments. Military trainers use a combination of training locations, methods, and technologies to provide training that is as realistic as practical in preparing people for combat. No training environment replicates combat, however; all reflect risk, availability, and cost.

Military ranges are an important part of the training environment. A range is a large area of land, sea and/or air space that enables military units to maneuver, and individuals in those units, from the commander to the individual sailor and Marine, to gain skills and experience in their prospective combat jobs. Military ranges that allow large-scale maneuver, accompanied by real firing of munitions from land, sea, and air units onto ground targets, are few in number. These ranges are often in competition with other domestic priorities (e.g., protecting the environment) for use of the same space. Nevertheless, the availability of real fire and maneuver ranges is essential for the readiness of the armed forces and the training of individual servicemen.

The Puerto Rico operating area has several training ranges that support naval training in surface, subsurface, air, strike, and amphibious warfare. The Vieques Inner Range, the range that will close in 2003, has historically been used to train Navy and Marine forces in amphibious warfare, although its value for this purpose has been limited over the last decade by restrictions placed on the range.

The Commander, U.S. Fleet Forces Command, has developed plans to improve existing East Coast training ranges over the next seven years. These plans fully address all warfare training (except amphibious warfare, which the plans only partially address). If fully implemented, the Commander's plans will result in a training environment that exceeds the capability of the present East Coast training ranges for all Navy warfare areas.

Fires training is essential

Real fires[1] training is critical for individual qualification training in all weapons, and for supporting unit-level and force-level fire and maneuver operational training. Real fires training is frequently cited by trainers as essential for creating a realistic training environment and for emotional conditioning of sailors and Marines. As our Senior Study Group observed, in training for combat, "warfighters must be exposed to three broad categories of stressors: handling live ordnance, delivering live ordnance in the proximity of (friendly) troops, and physical exposure to the effects and delivery of live ordnance." Analysis supports that conclusion, and the Analysis Team identified specific individuals (jobs) and units for whom real fire is a critical aspect of a particular training program.

The loss of the Vieques Inner Range: alternative methods exist

The Vieques range has been available to the Department of the Navy for more than a half-century. In the last decade, however, its use has been significantly restricted, and it is no longer providing the fire and maneuver opportunities desirable in training. The Bush Administration has decided to close the range in May 2003.

Closing the Vieques range most significantly affects amphibious warfare training, and particularly the integration of Naval Surface Fire Support in amphibious operations. Vieques has uniquely supported

1. Throughout this report we use the term real fires to refer to any weapon that has a trajectory through real space. We include explosive or inert ordnance, telemetry rounds, and sub-munitions. The more common term, live fire, refers only to delivery of explosive ordnance.

training for Naval Surface Fire Support, including qualification of ships, training of forward observers and fire support teams, and the integration of real fires in force-level amphibious/maneuver warfare.

Alternative training methods to replace the presently limited utility of the Vieques range do exist. In the immediate future, two actions can substitute for Vieques: first, deploy as planned the Virtual At-Sea Trainer, Deployable Prototype—the so-called VAST DP. This is expected to be available in Fall 2002. VAST is a portable, sea-impact acoustic scoring range that will support the formal training and qualification of ships and sailors in Naval Surface Fire Support of amphibious operations. This system, while it has limitations, appears capable of qualifying Navy ships in their fire support missions. Second, train East Coast forward observers and fire support teams at San Clemente Island, CA, the place where West Coast forces are trained.

A third immediate measure could further enhance amphibious training: allow real naval gunfire by qualified ships into Camp Lejeune, NC. Air strikes, mortar, and artillery fires already occur at Camp Lejeune ranges, but naval gunfire does not. Allowing naval gunfire could help in training force-level units in integrated fires. It would not need to occur on many days of the year (< 30 days). Our analysis indicates that the G-10 range at Camp Lejeune is capable of supporting naval gunfire, although only under tightly controlled circumstances that limit its full value for all but forward observer training. Alternatively, East Coast forces could simulate naval gunfire support with artillery, as is done by West Coast forces.

For the longer term, it may be possible to develop an alternative range that enables integrated fires training. In an earlier work, the Center for Naval Analyses identified several possible sites, and further sites have been identified within the Department of the Navy. Obviously, the costs and benefits for training at alternative sites would need to be evaluated.

Future training environments

Future weapon systems and concepts of operation will require access to large, contiguous land, air, and sea training areas. The Senior Study Group described the future as follows:

> Future naval forces will operate as smaller, widely distributed units conducting non-linear operations in frequently non-contiguous battle space, and the Joint Vision 2020 tenets of dominant maneuver and precision engagement will generate increased emphasis on the integration of fires and maneuver.

Present-day methods and ranges are suitable for training all currently documented operational concepts, as well as all future naval weapons systems except the Extended Range Guided Munition (ERGM). The ERGM will require training support that is more similar to the Tomahawk Land Attack Missile than to naval gunfire.

We analyzed the training environment required to support Expeditionary Maneuver Warfare, the concept for future Marine operations. Training to execute this concept will be possible using current ranges, provided they are netted together with new instrumentation that supports sensor and weapon information exchange. The simultaneous use of multiple ranges will require improved inter-Service coordination. Naval trainers must set requirements for instrumentation and for simulators that support their training goals in these new environments.

Future training: Role of instrumentation and simulation

Better instrumentation could significantly improve training. For all real fires, weapons detonation provides only limited technical feedback; training results would be improved by the addition of tracking and telemetry instrumentation. Simulators could also improve training, and partially substitute for real fires in training, if they can be made to accurately represent the distribution of weapon impacts. Future simulators that could realistically represent real fires, including naval gunfire, would improve fire-and-maneuver training for ships, aircraft, and ground units. Such simulators would increase training flexibility and training quality. Simulators do not, however,

produce the physiological responses to lethal stress that real fires produce, and therefore, while improving training would not replace all real fires training. Simulators would need rigorous validation to ensure they (1) accurately represent the performance of the actual weapon system, and (2) support the training and assessment standards prescribed by the trainers.

Recommendations

1. Implement the Training Resources Strategy developed by the Commander, Navy Forces Command.
2. Ensure the VAST DP acoustic naval gunfire mobile training range is ready for use prior to May 2003.
3. Fund the additional costs involved in training forward observers, fire support teams, and related personnel from East Coast units at San Clemente, CA.
4. Allow the use of real fires from naval guns into Camp Lejeune if the Marine Corps concludes this would usefully improve its combined arms-training.
5. Invest in new range instrumentation for automated tracking and assessment of all land-impact weapons.
6. Create a research and development program for developing and validating naval gunfire simulators that can support combined arms and integrated maneuver-fire training. Develop a simulator that will support Extended Range Guided Munition training.
7. Support the integration and coordination of all Service training ranges in order to increase training opportunities and improve training for all Services.
8. Investigate the feasibility of developing a new range for force-level naval combined-arms real fires training.

Introduction

The Secretary of the Navy asked CNA to consider and evaluate options for training naval forces in the future. His objective is to ensure that naval forces are ready for real-world operations. This training encompasses individual military personnel; units such as ships, squadrons, or battalions; and large forces such as battle groups and the Marine Air Ground Task Force.

This training prepares these various levels of naval forces for the challenges they could face in combat. Thus, it must prepare them to perform their tasks, no matter how complex, in the face of danger to themselves and others. (Preparing forces to perform in dangerous circumstances is a driving factor behind the use of real fire in training environments.) In doing our evaluation, we sought to understand the elements of training that are vital and those that are not. We also sought to understand what can be represented or simulated and what must be replicated and practiced. And we analyzed planned future systems and future operational concepts and what they will require in terms of an effective training environment. These requirements shaped our analysis.

Approach

The Senior Study Group met with training and operational commands from all four services. Their purpose was to gain a better understanding of the training required to accomplish the missions of the deployed forces. The meetings yielded information about what might be required for future training. The information we obtained influenced how we approached our analysis. That approach is described below.

Compare operational and training environments

Our first step in answering the questions posed by the Secretary was to specify how the current training environments compared to the actual operational environments. Once we understood how the training environments compared to actual operational environments, we assessed how the existing training environments supported the training requirements. Here we examined what responsibilities the training environment would support, the technology that was required to support the training of specific responsibilities, and the aspects of the real-world operational environment that required emotional conditioning.

Assess support of training objectives

Once we understood the various goals supported by the training environments, we had to understand how those goals translated to requirements of the training ranges. We identified the necessary control, or lack of control, required for the physical space of the range. Often, effective training requires less control than that necessary to use a range safely and not interfere with commercial and civilian activities. An example of this is airspace control. Effective air maneuvers require a large, unrestricted airspace that is rarely available in the vicinity of the continental United States. This need to physically control the range is often coupled with rules and regulations governing range use. Finally, environmental regulations must be followed for existing ranges and permissions granted for new range development.

Here the issue of training in the Puerto Rican operating area enters in the discussion of specific ways to support training requirements. The role of the Vieques Inner Range, including the live-impact area, has been addressed in a number of recent studies, including the Rush Report [3], the Fallon-Pace Report [4], and an earlier CNA study [5]. We drew on these reports, as well as additional sources and analyses, to address the role of the Puerto Rican training environment in Navy and Marine Corps pre-deployment training.

Assess support to future training

Finally, we considered the weapons and operational concepts envisioned by the Navy and Marine Corps for the future. By considering these future concepts relative to today's training requirements, we were able to articulate the trends for future training that current decisions must anticipate. We combined all of these analyses to offer specific recommendations about current and future training environments.

Key definitions

To discuss this analysis and the resulting recommendations, we must first present some definitions that are key to the analytic concepts presented in this report.

First, and most important are the definitions of *maneuver* and *fires*. In this report, the term *maneuver* applies to any force movement whether it is the classic maneuvers associated with ground elements or the movement of ships at sea or aircraft en route to or in a target area. Any force that is moving within an area to achieve an objective is a maneuvering force in this analysis.

In joint doctrine, *fires* refers to the effects of weapons. Because we are studying the training environment, we need to consider the trajectory of the weapon as well as its effects on impact. So we use the term *fires* to include the trajectory as well as the effects for all weapons. Anything that carries with it the ability to be lethal is part of fires for this analysis. We further defined the term *real fire* to refer to any weapon that has a trajectory through real space. We include explosive or inert ordnance, telemetry rounds, and sub-munitions. The common term *live fire* refers to delivery of explosive ordnance.

People are responsible for employing the fires. Some individuals in the fire employment process have enough information to predict the lethal outcome of the weapon they support. Not all in the firing process have that information. In this analysis, we consider those individuals who can predict the lethal outcome to have *lethal responsibilities*.

Lethal responsibility is an extremely important concept for this analysis and one that extends well beyond the trigger-puller. As an example, in an airstrike, someone identifies and selects the target to be struck and directs the aircrew to strike that target. In today's world, this person is often the Joint Force Air Component Commander (JFACC) but sometimes this responsibility goes as high as the Secretary of Defense and the President or as low as the forward air controller (FAC). Anyone who directs that a specific target be destroyed has lethal responsibility. The aircrew responsible for finding the target they have been directed to destroy and employing their weapons system against that target have lethal responsibilities. Aircrew employing long-range stand-off weapons do not. In our use of the term, the people on the ship who load the ordnance on the aircraft are vital to the process and require training, but they do not have lethal responsibility.

What is important about this concept of lethal responsibilities? We found that Navy and Marine Corps trainers place great importance on using live, explosive fires to train individuals to execute lethal responsibilities. We found that this was not consistently true for other Services or Joint training.

Organization of this report

This report summarizes the analytic effort for this project on future training options. The remainder of the paper describes our analytic approach.

In the next section we will describe the actual operational environment in analytic terms and then examine a variety of current training environments as compared to the actual operational environments. We will then explore the concept of emotional conditioning and how that requirement translates to training environments.

The majority of the paper will focus on the requirements of current and future training environments. This section will include all types of warfare the Navy and Marine Corps are engaged in and all levels of command that must be trained.

The report concludes with several specific recommendations for current training environments and for future combat training.

In the course of the study, we produced several other papers. References [6] and [7] address the importance and use of live fire. We published a separate paper [8] on future training requirements. And, finally, we considered the challenges of range management [9] and the political risks associated with range planning for the future [10].

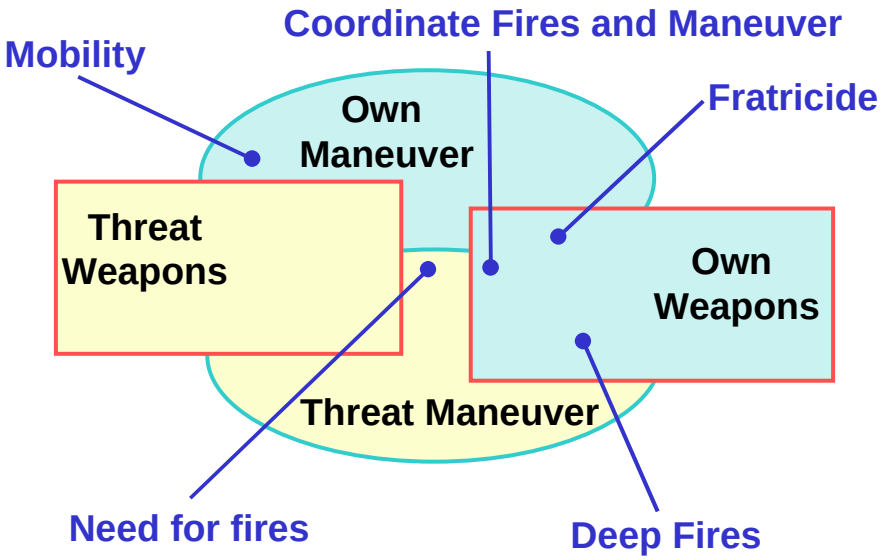
Operational and training environments

The Senior Study Group chairs described the major training regimens that the Navy and Marine Corps have put in place to meet the requirements of the deploying naval forces. The Navy's Inter-Deployment Training Cycle (IDTC) is characterized by individual, unit, and collective training, in situations of increasing complexity for the air, surface, and sub-surface components of Carrier Battle Group (CVBG). The Marine Corps conducts analogous, integrated Marine Air-Ground Task Force (MAGTF) and Amphibious Task Force (ATF) pre-deployment training. The training builds incrementally on individual and unit capabilities of the MAGTF command element and its major subordinate commands–the aviation, ground, and combat service support elements. For both the Navy and Marine Corps, the initial phases of training focus on individual and collective small unit training, The intermediate phase focuses on collective training, and the advance phase focuses on force-level evaluation. The Senior Study Group found that naval trainers employ appropriate training methods—the right set of events to prepare naval forces to deploy. Armed with that information, the analysis team examined the training environments that accompany these events in order to understand how those environments support the required actions and decisions in actual operating environments.

At the most basic level, the real-world operational environment consists of our operating space and weapons and the threat's operating space and weapons. The operating spaces correspond to the maneuver spaces and the weapons correspond to fires. The size of our maneuver space determines our mobility. The extent of overlap in the threat's maneuver space with ours represents the area where there is a direct threat to our forces and a corresponding need for fires. Where our weapons overlap the threat's maneuver space, we have the opportunity for deep fires. Where our weapons overlap our own maneuver space, we have the risk of fratricide. And, finally, where our weapons overlap both our space and the threat's, we have

the requirement to coordinate maneuver and fires. These concepts are illustrated in figure 1 below. Analytically, this depiction represents the real-world operational environment that the training environment must replicate to varying degrees of fidelity.

Figure 1. Depiction of operational environment

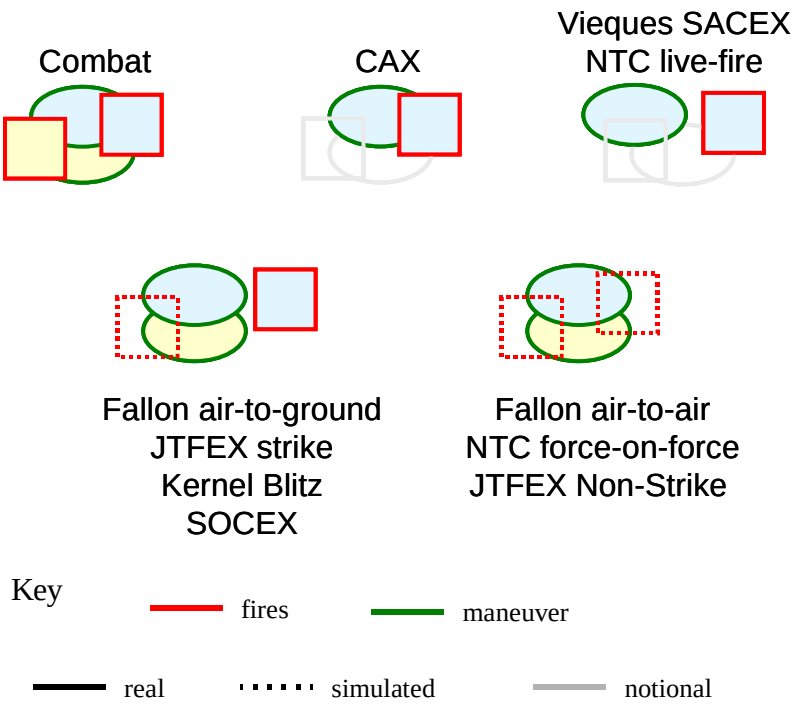


How do current training environments achieve this?

Figure 2 depicts the comparison of the major training events conducted today based on the depiction of combat presented in figure 1. The first thing that is clear from figure 2 is that no training environment can provide force-on-force engagement involving exchange of real fires. Second, the Marine Corps Combined Arms Exercise (CAX), run by the Marine Corps Air-to- Ground Task Force Training Center (MAGTFTC), Twenty-Nine Palms, CA, is an example of training that has overlap of fires and maneuver. The Supporting Arms Coordination Exercise (SACEX) frequently conducted at Vieques, and the live-fire training conducted at the National Training Center (NTC), do not have overlap between maneuvering ground forces and the area where force fires are conducted. Other training exercises—Fallon air-to-ground events, Joint Task Force Exercise (JTFEX) strike

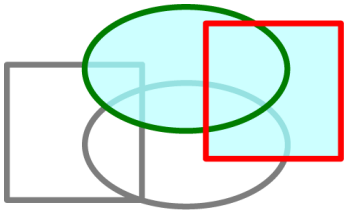
training, the annual Kernal Blitz exercise at Camp Pendleton, and the Special Operations Capable Exercises (SOCEXs)—do have force-on-force maneuver opportunities, but the live fire portions of the training are conducted separately from the maneuver areas. These exercises also include simulated threat fires against the maneuvering forces. Finally, there are training events that have only simulated fires but include force-on-force maneuvers. These are Fallon air-to-air training, the NTC force-on-force exercises, and all elements of the JTFEXs other than strike warfare.

Figure 2. Comparison of training and operational environments



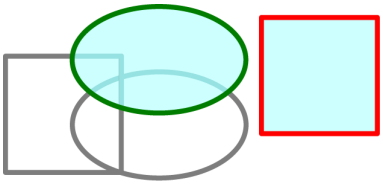
Each of these environments represents a different focus for the training.

Overlapping Fire and Maneuver



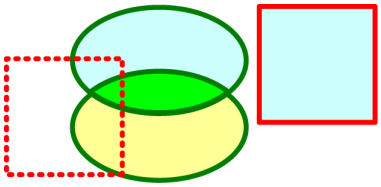
These exercises focus on the coordination necessary to safely employ live fires in the proximity of maneuvering friendly forces.

Displaced Fire and Maneuver



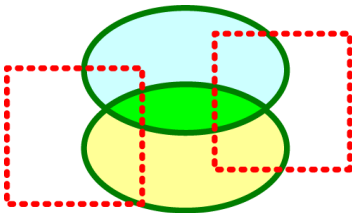
Here the training allows for concurrent fires and maneuver but does not emphasize the coordination as in the first case.

Force-On-Force with simulated threat weapons



These types of training events focus on the employment of fires with supporting maneuvers against an opposition force.

Force-On-Force with simulated weapons



Finally, in the events where all fires are simulated, the focus of the training is on the ability to maneuver against a live opposition force.

By looking at these pictures, it is clear that the current training environments focus on different elements of the actual operational environment. It is also clear that only the first environment, such as currently experienced in the CAX training program, provides any opportunity for the participants to experience the emotional conditioning associated with operations in proximity to deadly fires.

Emotional conditioning and lethal responsibilities

In this section we explore in detail the issue of training in proximity to deadly fire. In the Senior Study Group's view, live fire is essential to ensuring forces are ready because such training affords its audience the greatest degree of realism. In the group's view, accommodating this realism, especially for large numbers of participants conducting integrated maneuver and live fire training, is one of the fundamental challenges to providing the most effective training for naval forces. The group also stated that the ideal training would involve sailors and Marines having to consider the mission, enemy activity, weather, and terrain all while under pressures of time and realistic stresses. The group cited three broad categories of stressors: (1) handling live ordnance; (2) delivering live ordnance in proximity to troops; and (3) physical exposure to the effects of ordnance delivered in proximity.

Senior Study Group members also commented on the contribution constructive and virtual training make to the overall training effort. The group saw constructive training, which it defined as training involving the use of artificial environments, as effective for developing procedures and staff techniques. The artificial environment allows training to occur without the unit having to deploy to the training site. Constructive training also eliminates the risks associated with live fire.

As for virtual training, which the Study Group defined as training that replicates weapon systems and environments with varying degrees of realism, the group thought that this type of training facilitates repetitive learning and experiments without the risk of live force. It also takes place at a modest cost in relation to the actual platforms it replicates. In the opinion of the Study Group, virtual training cannot replace live training even though it successfully replicates many

aspects of the systems, the environment, and the mission performance. The group concluded that there is no substitute for live training. Virtual and constructive training serve to enhance live training, particularly when they are used to prepare units for live fire.

Nevertheless, the Senior Study Group also noted that currently the proportion of live fire to constructive or virtual training is high but that at some point in the future there could be greater reliance on the latter forms of training. This finding suggested the need to examine closely when and why live fire is needed in training. This need was reinforced when we, along with the Senior Study Group, considered how other services use live fire in training. For example, the Army considers live fire an absolute requirement for training. Nevertheless, its approach to training shows an effort to achieve a balance between live fire and simulation (the Army refers to simulators and related items as Devices, Simulators, and Simulations or DSS). While the Army continues to push for advances in DSS, it feels that events that "put steel on target" provide an intensity not encountered during constructive or virtual training, which is important in assessing the readiness of a unit. This finding, together with the Senior Study Group's statement that the need for live fire could change in the future, propelled us to look at when and why live fire is important in training. To conduct this analysis, we looked at the issue of emotional conditioning, which we describe in the following paragraphs.

Emotional conditioning

We focused on three aspects of the employment of deadly fires in this analysis.

First we looked at the implications of operating *near* explosive munitions or fires. This includes the process of building, handing, and transporting explosive ordnance, which is important to ordnance handlers. It also includes the act of maneuvering in the proximity of deadly fires, such as those experienced by infantry forces and strike aircraft. When operating near fires, individuals are concerned with the physical effects on themselves and on other friendly forces operating near the weapons and fires.

The second aspect we considered was the process of targeting deadly fire. This involves the process of assigning weapons impact points for deadly fire. There are many examples of this aspect of live fire including the pointing and shooting of infantry, the target acquisition and weapons employment process of strike aircraft, the designation of targets by forward air controllers and the assignment of targets and designated mean points of impact (DMPIs) on the air tasking order (ATO) by the JFACC. The concern here is the effect of the target assignment on the people near the planned impact position.

Finally, we looked at the process of allocating deadly fires. This process involves allocating fires in support of your own forces. This includes the actions of squad leaders, force-fires coordinators, and JFACCs. The concern here is for the forces' survivability and effectiveness and the ability of the fires to support them.

To better understand the issue of emotional conditioning in the context of these three aspects of employing deadly fires, we did research on what is currently understood regarding individual stress [6]. The research identified that certain types of events can place individuals under extreme stress. We assume that one example of this is exposure to the risk of physical harm or death. We found ample evidence that training can reduce the negative effects of stress.

For example, to prepare individuals to perform effectively in the face of this extreme stress, the research suggested that it is useful to "overtrain" the skills most critical to effective performance without the stress included in the training environment. Fundamentally, this suggests that basic procedures, such as safety, weapons handling and communication procedures, be trained repetitively.

The research also suggested the importance of training the more complex processes in the presence of stress in the training environment. This training under stress addresses the cognitive, planning, decision, and team skills that are so important in live combat. By training these complex processes in the presence of stress, it improves the individual's ability to better assess and manage the stress when confronted with it in the real world. For our study, this suggests that the adaptive processes, such as coordinating maneuver and fire and

using combined arms, would benefit from training with the stress of live fire.

Finally, our research on stress suggested where simulators might be useful in training for stress. Simulators can be designed to provide high-task loading, group pressures, intense sensory loading, and time pressures. Simulators can also be used to help maintain these skills once attained. But there are other stresses that simulators cannot support. These are primarily the stresses associated with physical, emotional, and mortal threats. Therefore, simulators cannot provide adequate training for managing these stresses.

The role of live fire, inert ordnance, and simulations

We identified four primary training objectives that need to be met when training for fires:

- The procedures used to employ the fires
- The ability to control the fires
- The effects of the fires once employed
- The emotional conditioning necessary for operating in the proximity of lethal fires.

Our analysis of the current fleet training program showed that there are three primary uses of live fire in training [7]. First are the basic weapons qualifications necessary for the employment of all weapon systems. Second is the process of coordinating fire and maneuver together. And finally, there are the higher level issues associated with the employment of force fires. These aspects of the training environment are depicted in matrix format in figure 3. The figure also includes some questions and phrases intended to capture the focus of each cell in the matrix. For example, training the ability to control fires for weapons qualifications training is the degree of precision achieved in weapon employment. For force-level fires, decision-makers "control" the allocation of fires rather than their accuracy. At this level, control is the ability to control your available fires in such a way that they are allocated to the places you most need them.

Figure 3. Training objectives for weapons, fire-maneuver, and force-fires training

Training Objective	Weapon qualification	Fire and maneuver	Force fire
Procedures	**Weapons** Proper prep and firing?	**Tactical** Fire and maneuver coordinated?	**Force** How were fires allocated?
Control	**Precision** Hit intended aim-point?	**Accuracy** Fires hit correct target?	**Allocation** Desired allocation achieved?
Effects	**Weapons** Assess weapon effects?	**Tactical** Fires achieve tactical objective including combined arms?	**Force** Did allocation support force objectives?
Emotional conditioning	Handling live rounds, firing weapon, experiencing weapons effects	Target selection and coordination of fires and live forces	Support of unit and force needs to survive and achieve objectives

Given this live fire training matrix, we can ask what the employment of explosive, inert, and simulated fire provides for each cell.

Explosive fires

Figure 4 shows how explosive fire supports the training required by each cell. From the figure it is clear that live fire fully supports the training objectives for nearly all the cells in the matrix. However, explosive fires to support training of fire and maneuver is inherently dangerous and the CAX program is one of the few examples of its use. Explosive fire can only train force fires *procedures* and support an assessment of the effectiveness of *controlling* the desired allocation of fires. To assess force *effects*, attrition of the opposing forces must be simulated.

Inert fires

Figure 5 shows this assessment with the use of inert ordnance. Here inert ordnance supports training procedures and control for all fires, but an assessment of the effects relies on simulations. Because the effects are simulated, inert ordnance cannot train the emotional conditioning necessary at the weapons qualification level. The fire and maneuver cell is "green" for emotional conditioning because an inert round passing through the maneuver space can still have a lethal effect.

Figure 4. Support of training objectives by explosive fire

Training Objective	Weapon qualification	Fire and maneuver	Force fire
Procedures	**Weapons** Proper prep and firing?	**Tactical** Fire and maneuver coordinated?	**Force** How were fires allocated?
Control	**Precision** Hit intended aim-point?	**Accuracy** Fires hit correct target?	**Allocation** Desired allocation achieved?
Effects	**Weapons** Assess weapon effects?	**Tactical** Fires achieve tactical objective including combined arms?	**Force** Did allocation support force objectives?
Emotional conditioning	Handling live rounds, firing weapon, experiencing weapons effects	Target selection and coordination of fires and live forces	Support of unit and force needs to survive and achieve objectives

Fire supports training objective
Fire supports training objective using models and simulation
Fire cannot support training objective

Figure 5. Support of training objectives by inert ordnance

Training Objective	Weapon qualification	Fire and maneuver	Force fire
Procedures	**Weapons** Proper prep and firing?	**Tactical** Fire and maneuver coordinated?	**Force** How were fires allocated?
Control	**Precision** Hit intended aim-point?	**Accuracy** Fires hit correct target?	**Allocation** Desired allocation achieved?
Effects	**Weapons** Assess weapon effects?	**Tactical** Fires achieve tactical objective including combined arms?	**Force** Did allocation support force objectives?
Emotional conditioning	Handling live rounds, firing weapon, experiencing weapons effects	Target selection and coordination of fires and live forces	Support of unit and force needs to survive and achieve objectives

Fire supports training objective
Fire supports training objective using models and simulation
Fire cannot support training objective

Simulated fires

Finally, figure 6 depicts the ability of simulated fires to support the training requirements. As for other types of fires, simulated fires can support training of procedures; for force fire, simulation supports a determination of the allocation of fires. However, simulated fires simply cannot support the training requirements associated with emotional conditioning. There are also many more cells where modeling and simulation must be used to assist the training and achieve the requirement.

Figure 6. Support of training objectives by simulated fires

Training Objective	Weapon qualification	Fire and maneuver	Force fire
Procedures	**Weapons** Proper prep and firing?	**Tactical** Fire and maneuver coordinated?	**Force** How were fires allocated?
Control	**Precision** Hit intended aim-point?	**Accuracy** Fires hit correct target?	**Allocation** Desired allocation achieved?
Effects	**Weapons** Assess weapon effects?	**Tactical** Fires achieve tactical objective including combined arms?	**Force** Did allocation support force objectives?
Emotional conditioning	Handling live rounds, firing weapon, experiencing weapons effects	Target selection and coordination of fires and live forces	Support of unit and force needs to survive and achieve objectives

Fire supports training objective
Fire supports training objective using models and simulation
Fire cannot support training objective

Summary

From this analysis, we conclude that simulations are useful for training procedures under the stresses associated with group, time, and sensory overload stresses; however, simulations are not able to train the emotional conditioning necessary to operate with the stress of physical, emotional, and lethal threats. However, we found little research that directly addresses this issue. Given the expense of training simulators and live training, we believe that DoN should pursue

research articulating what skills and behaviors simulators can, and cannot, train.

We also see that the requirements for emotional conditioning are very different when operating near deadly force than for targeting or allocating fires. Only live fire is sufficient to aid in the emotional conditioning necessary to effectively operate near deadly force. Inert fires are sufficient to provide the emotional conditioning necessary to target the fires; yet, no current training method exists that provides the emotional conditioning associated with the allocation of force fires.

Lethal responsibilities

We defined the term lethal responsibilities earlier in this paper. As we explore the training significance of lethal responsibilities in this section, it is important to remember that lethal responsibility is associated with any individuals who can predict the lethal outcome with their weapons employment decision. Conversely, if individuals cannot not determine the lethal outcome of their employment order or decision, they do not have lethal responsibilities as defined here.

Both targeting and maneuver decisions can have lethal responsibilities. For example, an individual who chooses a target and has knowledge of what effect firing against that target would have on enemy, friendly, or neutral forces has lethal responsibility. Similarly, an individual who directs maneuvers with knowledge of the effect those maneuvers will have on the exposure of the maneuvering forces to enemy or friendly fires has lethal responsibilities. An individual can direct himself or the actions of others. Through our analysis, we identified that the individuals with lethal responsibilities drive the focus of the training program. In the next section we identify the individuals with lethal responsibilities for each of the warfare areas important to naval forces.

Who has lethal responsibilities?

To see how these concepts applied, we considered five warfare areas: surface warfare (SUW); strike operations, including both air-to-air

and air-to-ground; naval surface fire support (NSFS); and littoral/ground operations.

For SUW, three individuals have lethal responsibilities. The Sea Combat Commander (SCC) orders the engagements on hostile targets and the Commanding Officer (CO) and Tactical Action Officer (TAO) maneuver the ship and identify the targets for engagement.

For strike operations, the JFACC has lethal responsibilities in that he assigns strike platforms and weapons systems to particular targets and aimpoints. For some weapons, the aircrew themselves identify and release ordnance against the targets and, therefore, also have lethal responsibility. Conversely, the officer who fires the TLAM in response to an order from the JFACC does not have lethal responsibility. The TLAM shooter has no information to allow him to predict the lethal outcome with the TLAM employment but rather does what the JFACC directs. For the air-to-air portion of strike warfare, the element lead who sorts and assigns the threats, and the aircrew who locks and shoots the target and is responsible for re-attacks, both have lethal responsibilities.

The forward observers, who provide the firing coordinates, order the fires on those coordinates, and correct fires based on their outcome, have the lethal responsibility for indirect NSFS missions.

Finally, for Expeditionary Maneuver Warfare (EMW), there are several types of lethal responsibilities. The first category are those individuals responsible for ordering and/or marking fires on coordinates, correcting those fires, and de-conflicting the fires. The fire support team (FiST), including the forward air controller (FAC) for air support and the forward observer for gunfire support, all have this type of lethal responsibility in EMW. For air support, the aircrew who actually acquire and engage the target directed by the FAC shares lethal responsibility. Once the transfer of forces to shore has occurred, the ground combat element (GCE) has the lethal responsibility associated with directing the maneuver of the forces into harm's way.

Training lethal responsibilities

Some might suggest that it is necessary to train lethal responsibilities using lethal methods; however, by examining current training we found that only a subset of individuals with lethal responsibilities are actually trained through the application of real fires.

Specifically, real fire training during weapons qualification trains the TAO in surface warfare but not the SCC. Similarly in strike training, only the aircrew who locks the target in air-to-air combat in the presence of the drone launch aircraft, gains direct training in lethal responsibilities from real fire weapons training. Finally, the forward observer in NSFS is trained in today's weapons qualification training events.

In today's training environments, only EMW and ground combat use real fire to train lethal responsibilities associated with maneuvers. This training occurs in exercises that combine maneuvers with real fires, such as CAX, and in the training that occurs for naval fires (NSFS) at Vieques for the East Coast and San Clemente Island on the West Coast.

Summary

In this section we examined two important related concepts when preparing forces for live combat: emotional conditioning and lethal responsibilities. We found that weapons qualification training requires real fire to train both the emotional conditioning and lethal responsibilities necessary to employ real weapons in combat.

We also found that only *real fire* is sufficient to aid in the emotional conditioning necessary to effectively operate near deadly force. Correspondingly, we found that only Expeditionary Maneuver Warfare and ground combat actually use real fire in today's training environments to train maneuver as well as the employment of fires. This analysis suggests that this current training is very important to prepare these forces to operate in proximity to deadly force in real combat.

Requirements for current training environments

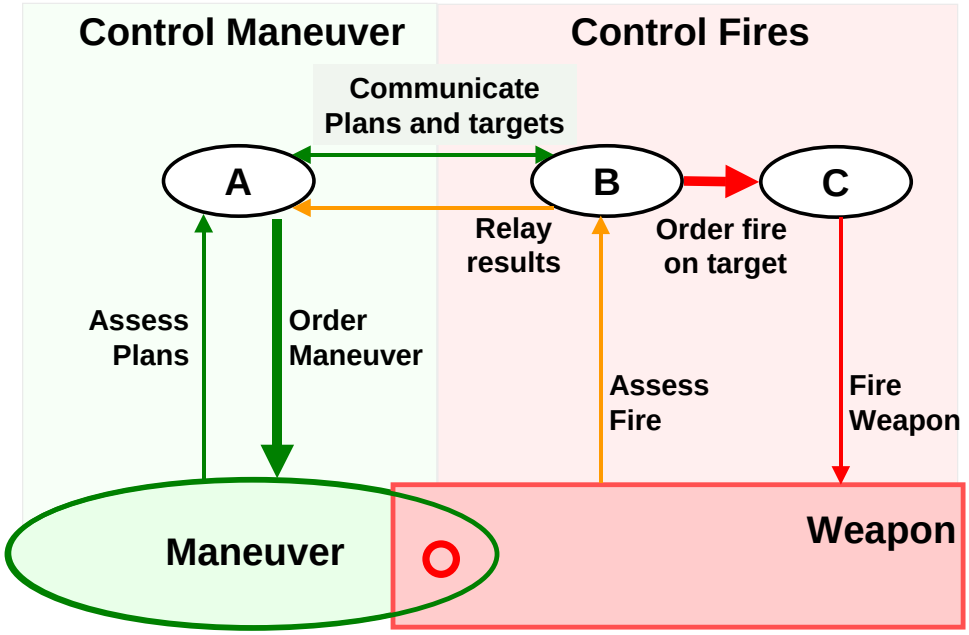
We have examined how the forces are currently trained and what emotional conditioning and training for lethal responsibilities that training provides. In this section, we will determine the requirements for the current training environments. To do this, we will first introduce *decision responsibility templates* for each of the naval missions. Through these templates, we will identify who has responsibilities in maneuver, fires, and coordinating maneuver and fires and what those responsibilities are. We do this for all levels of command—from force commanders to individuals firing weapons. Finally, we will analyze how the various training environments affect the training of these mission responsibilities and from this analysis, identify the requirements for current training environments.

Decision responsibility templates

Figure 7 illustrates a decision responsibility template. The green oval and red box at the bottom represent the same maneuver and weapon space presented in figure 1, but are limited to only friendly fire and maneuver spaces. The red circle in the intersection of the fires and maneuver boxes represents the point of weapons impact. On the maneuver side of the figure, person A is responsible for assessing plans and ordering maneuver. Person B develops a plan for employing fires to support A's overall plan, including A's scheme of maneuver. Person B coordinates his plan with A, typically through target lists, to ensure that the fires support the overall plan.

Person B orders person C to fire on the target. Person C, on the fires side of the figure, is then responsible for firing the weapon and getting the assessment of that weapons firing back to person B, who relays the results to person A. Person A could then order new maneuvers based on this result.

Figure 7. Generic decision responsibility template



This diagram illustrates the relationships between fire and maneuver decisions for a generic case. It also shows how certain individuals can be identified as having decision responsibilities. The green lines in the figure are associated with maneuver decisions, red lines for firing orders and actions, and yellow lines for firing assessments. The heavy lines indicate lethal responsibilities.

Figure 7 is the generic figure for decision responsibilities when friendly maneuver and fires spaces overlap and real fire is employed in the training. Figure 8 illustrates the difference when fire and maneuver are geographically separated, or displaced. Modeling and simulation would translate the location of the fires experienced in the training, indicated by the solid red circle, to the location in proximity to the friendly forces, indicated by the dashed red circle. The dashed line joining them represents the model or simulation that translates the fall of fire into the maneuver space. By comparing figures 7 and 8, it is clear that separating the maneuver and fires eliminates lethal responsibilities. Otherwise, all decisions are the same.

Figure 8. Decision responsibility template: displaced fires

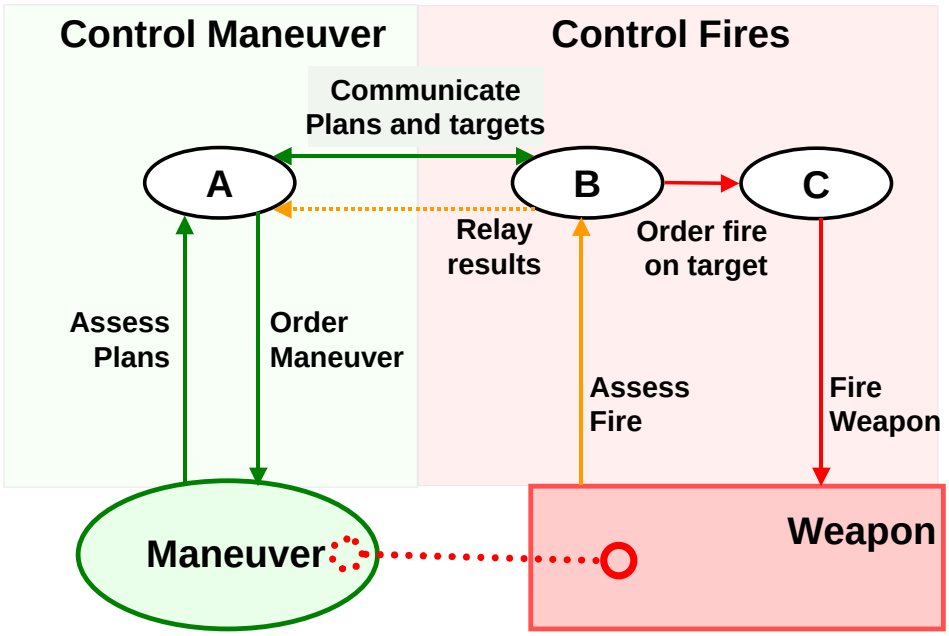


Figure 9 shows how the elimination of all real fires would affect the generic decision responsibilities template. Now, not only are there no lethal responsibilities but there is no ability to fire and, therefore, to assess the effects. In this case, only maneuver and firing orders are actually experienced in the training.

Finally, figure 10 shows how this template develops with the addition of threat maneuver and fires. Now, the assessment of the status of the plans is dependent upon information from the maneuver of the friendly forces: (1) the green line that was present in figures 7 through 9: (2) information available regarding the enemy's maneuver, the blue line, and, finally, (3) information regarding enemy fires, the red line. These three sources of information are also vital in the coordination of friendly maneuver and fires. Information from all three of these components are combined with the assessment of friendly fires, joining from the weapons side of the template through the gold line, and are used to determine the next start of the cycle represented in the decision responsibility template.

Figure 9. Decision responsibility template: simulated fires

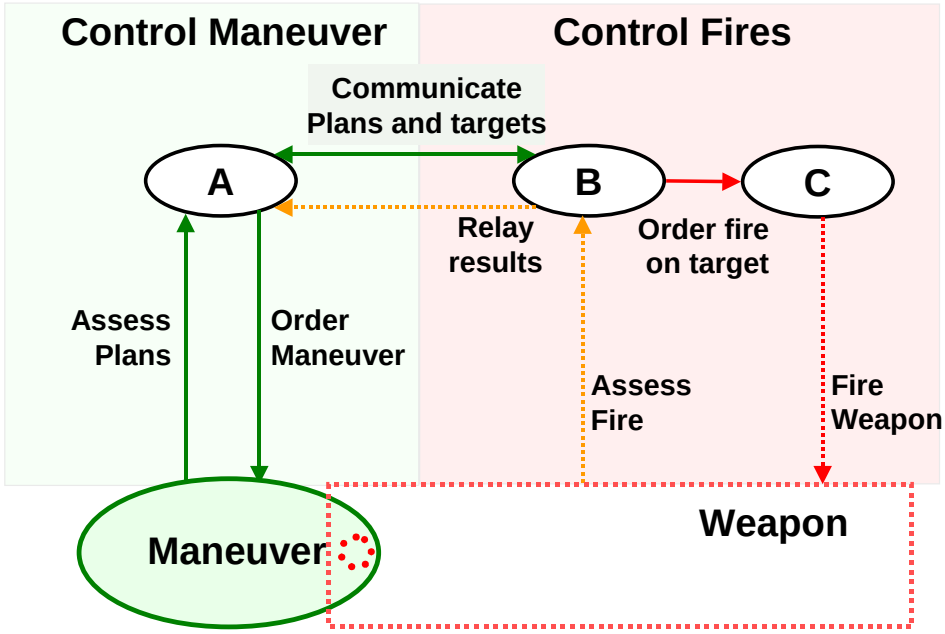
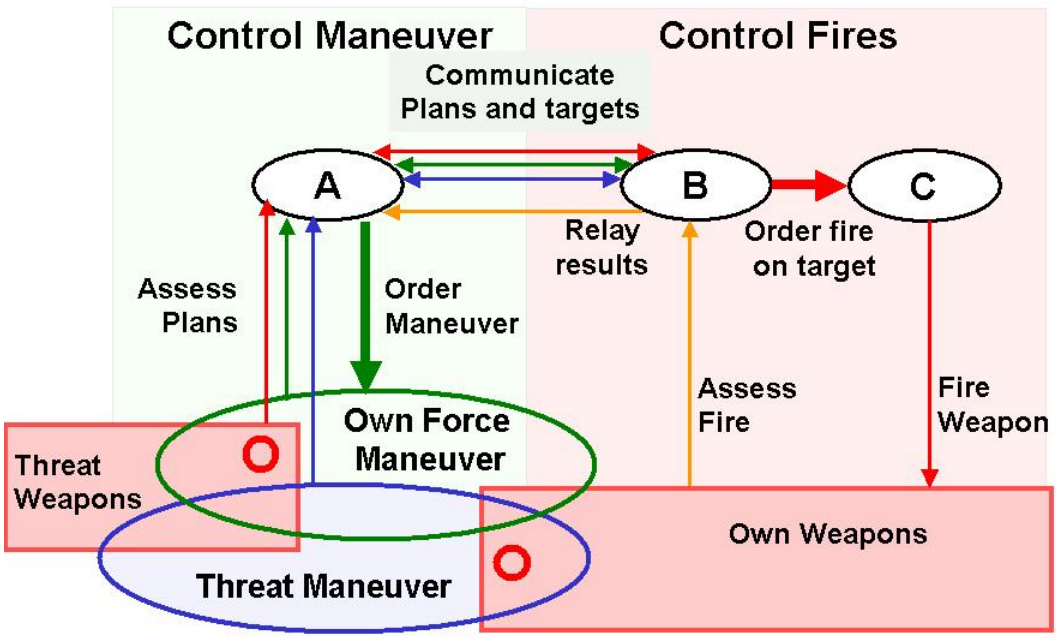


Figure 10. Feedback from threat weapons and maneuver

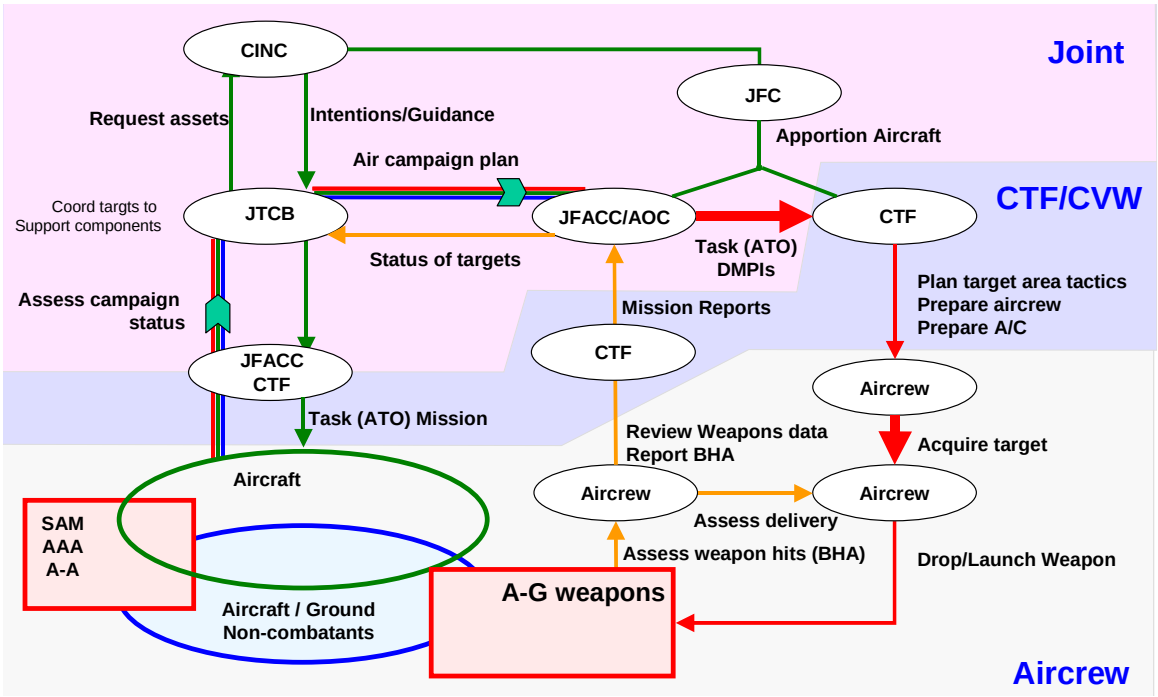


Decision responsibility templates: Joint strike warfare

Given the concept of a decision responsibility template, we can now apply that concept to each of the warfare areas important to naval forces. First we will look at naval participation in joint strike warfare.

To consider the decision responsibilities for joint strike warfare, we need to look at three levels of participation: the joint commander level, the carrier task force (CTF) and carrier airwing (CVW) levels, and the decisions made by the aircrew themselves. Figure 11 depicts the decision responsibility template for all three of these levels for joint strike warfare.

Figure 11. Decision responsibility template: CVW in support of joint strike warfare



The maneuver side of the template involves primarily joint commanders. The commander of the task force is responsible for providing the strike aircraft to the JFACC but, once launched, the aircraft work directly for the JFACC. The commander of the task force (CTF) is responsible for ensuring that the aircraft are available to execute the missions assigned in the air tasking order (ATO). The JFACC is responsible to the CINC for overall strike campaign decisions to support the commander's intentions, including target and aimpoint selection. As the orders are passed over to the weapons side of the template, they are passed through joint commanders to the CTF, who is responsible for planning target area tactics and preparing the aircrew to conduct the mission. The aircrew themselves have clear responsibilities, all of which are on the weapons side of the template. The reporting responsibilities are fed back through the CTF to the JFACC.

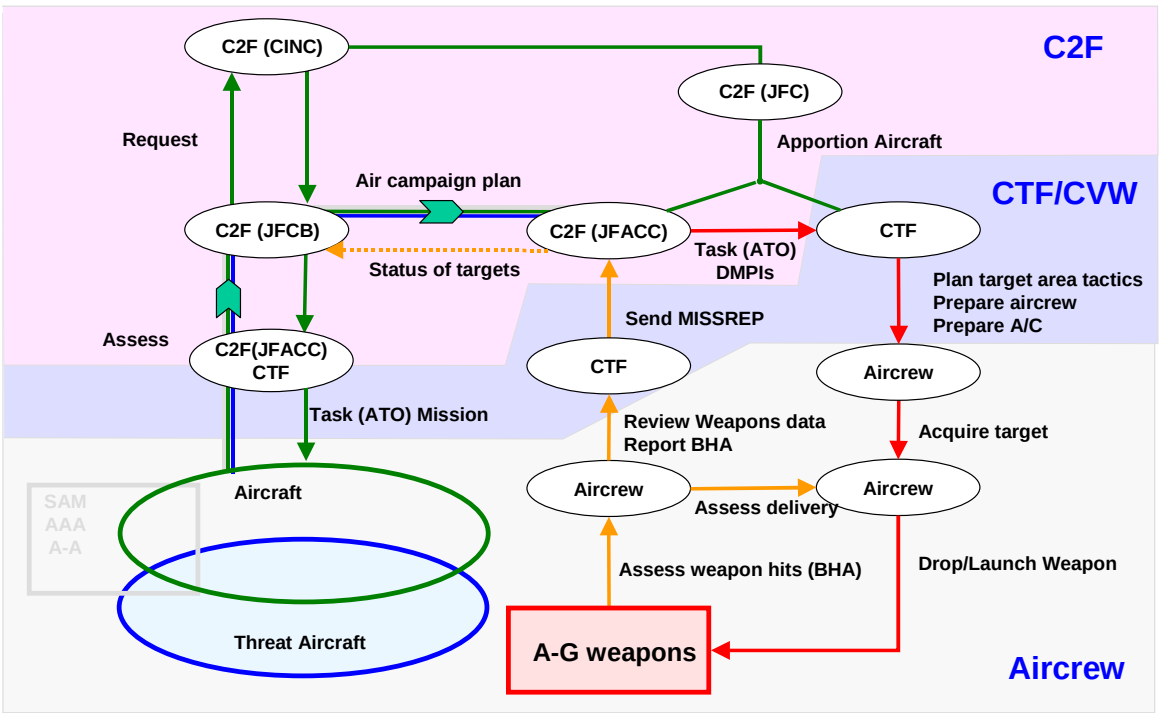
From figure 11 it is clear that lethal responsibilities lie with the JFACC—who assigns the routes for the aircraft to get to the target area, and the targets and aimpoints for attack through the ATO. Lethal responsibilities also lie with the aircrew themselves, who maneuver in the target area, acquire the targets, and employ their weapons against them. When the aircrew do not acquire the target, such as for GPS-guided weapons, the aircrew do not have lethal responsibility. It is also clear that actions of the threat, whether it is relocating the air defenses or actually employing surface-to-air missiles (SAMs), anti-aircraft artillery (AAA), or enemy fighter aircraft, are important in formulating plans regarding the employment of strike assets.

Vieques-based joint strike training

Figure 12 depicts how the training of joint strike was conducted for carrier battle groups at Vieques training range in Puerto Rico during the joint task force exercises (JTFEX). In the training exercise, all the joint functions were simulated by Commander, Second Fleet (C2F), who was responsible for conducting the training. Also, the aircrew conducted their live fire training on targets distant from any real forces (although the range control officers were at lethal risk). Relative to the actual strike environment, no lethal responsibilities were trained at Vieques, but most of the key decisions were represented.

Also, the process of building and loading explosive ordnance for the carrier was exercised. This training is important because it provides emotional conditioning for the ordnance handlers (discussed earlier). It is also important for high volume strike operations, such as large deliveries of Mk 80 series unguided munitions. Building and loading ordnance in high volume operations requires practice [11]. The weapons must be moved to the flight deck in a way that is synchronized with the flight operations. This was also practiced at Vieques. The only part of the process that had to be simulated was the assessment of the results of the strike and the feedback of that assessment to the JFACC. These actions are represented by the dashed gold line in figure 12.

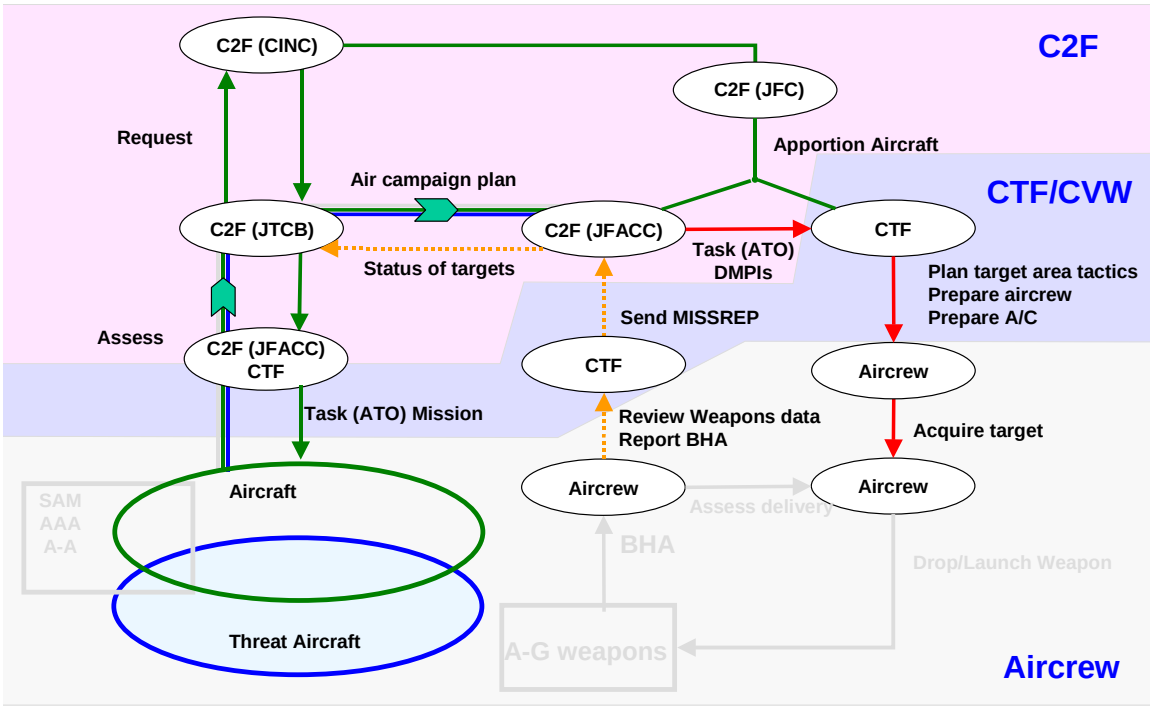
Figure 12. Vieques joint strike training



When strike training does not include employment of actual ordnance, the bottom portion of the joint strike responsibility template is omitted (shown in figure 13). Now, in addition to not training the

aircrew in weapons employment, the assessment of the strike results from the aircrew is simulated as well as the assessment from the CTF to the JFACC. However, the CTF training is still supported even without weapons delivery because the CTF still prepares the aircraft and aircrew for strike operations.

Figure 13. Joint strike training without ordnance drops



Aircrew training in JTFEX

From analysis of strike performance in real-world operations [12], we found that the most significant aspect of aircrew training was the focus on weapons employment early in the workup cycle through events like the strike fighter advanced readiness program (SFARP). Combat performance—specifically the employment of precision-guided and supported munitions such as laser guided bombs varied considerably between those aircrew who had participated in SFARP

and those aircrew who had not. These precision, supported weapons made up about 75 percent of the weapons employed by naval forces in recent combat (Desert Fox, Allied Force, OEF [13]). Even for very experienced aircrew, we still saw that recent participation in SFARP improved their performance when employing these types of weapons in combat.

For GBUs, we also found a steep learning curve in the performance of the aircrew with a correspondingly quick decay in the skills gained. The aircrew's learning curve was influenced by their prior participation in SFARP. Aircrew who attended SFARP started with a higher hit rate and maintained a higher hit rate and steeper learning curve when compared to those aircrew who did not attend SFARP. In other words, the non-SFARP aircrew were never able to catch up to the performance of the SFARP-trained aircrew during combat.

In cases where aircrew were given the opportunity to make up for an inability to participate in SFARP by conducting bomb dropping exercises at ranges such as Vieques, we did not see a correspondingly higher performance in combat like we did for those aircrew who participated in SFARP. The feedback the aircrew receive at SFARP, coupled with the focused nature of the training on specific aspects of weapons system employment, is not replaced by opportunities to deliver live ordnance without the focused training support.

Finally, when we looked at reasons for not hitting the target in combat operations, we found that the single largest problem was target acquisition [14]. In addition to being difficult to do, it represents a lethal responsibility on the part of the aircrew.

Figure 13 illustrates the importance of identifying the training audience. In joint strike warfare, lethal responsibilities are shared by the JFACC and the aircrew. In the JTFEX, the JFACC is simulated and therefore not part of the training audience, but the aircrew are trained in their portion of the lethal responsibilities—target acquisition. From the figure it is also clear that, since the aircraft do not drop weapons, the assessment of the strike outcome has to be simulated. Since the assessment of weapons effects on the target most affects the decisions of the JFACC and the JFACC is simulated by C2F, there is really no negative effect on the training of the CTF/CVW.

Decision responsibility templates: EMW

Expeditionary Maneuver Warfare is associated with a very complex decision responsibility template. The maneuver aspects of the template are first associated with the transition from sea to shore, often in the presence of enemy forces. The firing side of the template involves artillery/mortars, aircraft, and naval gunfire support. It is the job of the FiST to order fire and deconflict the types of fires. The forward observer, an element of the FiST, calls for and corrects fires and the forward air controller, another element of the FiST, deconflicts air activity and directs air support. The FiST, including all its elements, has lethal responsibilities.

Of the firing units themselves, only the aircraft have lethal responsibilities as they are the only firing participants who actually acquire the target in response to direction by the FAC. The other firing units fire their weapons on coordinates provided by the FiST or the FO and, therefore, do not share lethal responsibilities. Information about the maneuver and weapons for both hostile and friendly forces must be coordinated between the maneuver and fire sides of the template for EMW in the same way that it is vital to coordinate for ground combat. And, finally, there are many levels of command that have decision responsibilities in EMW ranging from, for example, in an amphibious operation, the company level all the way up to the Commander, Amphibious Task Force (CATF) and the Commander, Landing Force (CLF). All of this is illustrated in figure 14 for an amphibious landing, which is representative of the mission supported by Vieques.

Figure 15 depicts how the decision responsibilities were trained on the Vieques training range. From the figure you can see that the maneuver area was separated from the firing area at Vieques. Therefore, simulation was required to provide the information about friendly and threat maneuver and fires necessary to assess plans and coordinate maneuver and fires. However, the coordination between maneuver and fires was fully represented at the highest level of command and control shown on the template and the lethal responsibilities indicated on the firing side of the template were trained, including airspace control. It is important to note, however, that the lethal responsibilities of the FiST were trained only with regard to the safety of the forward observer.

Figure 14. Amphibious landing decision responsibility template

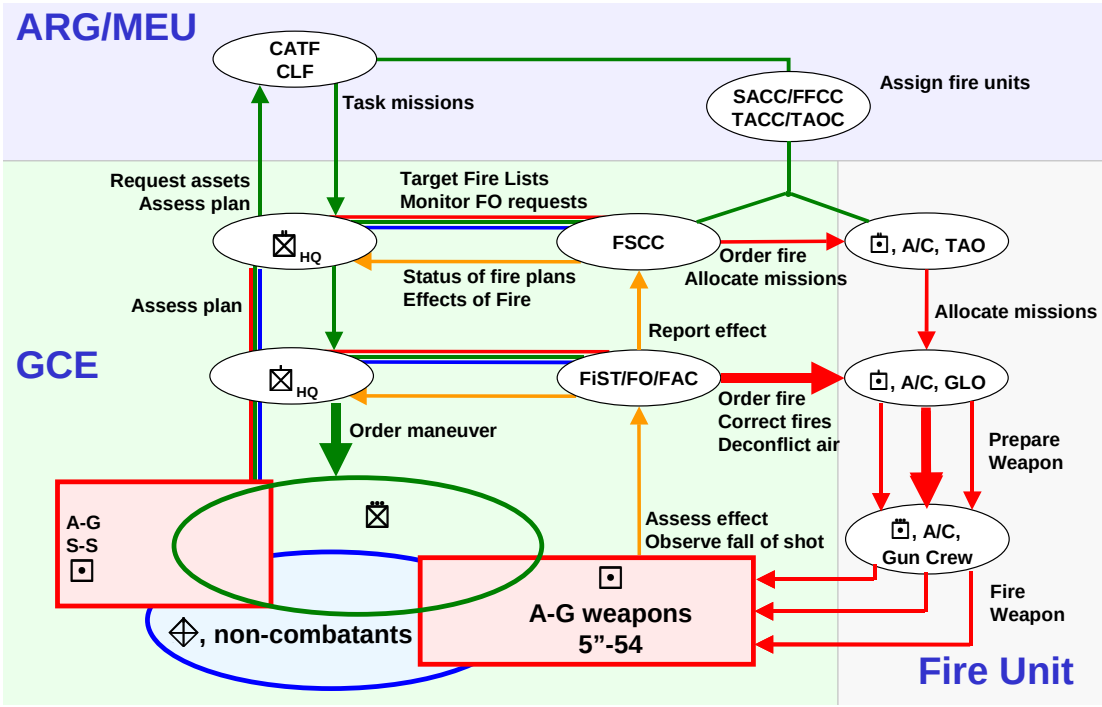
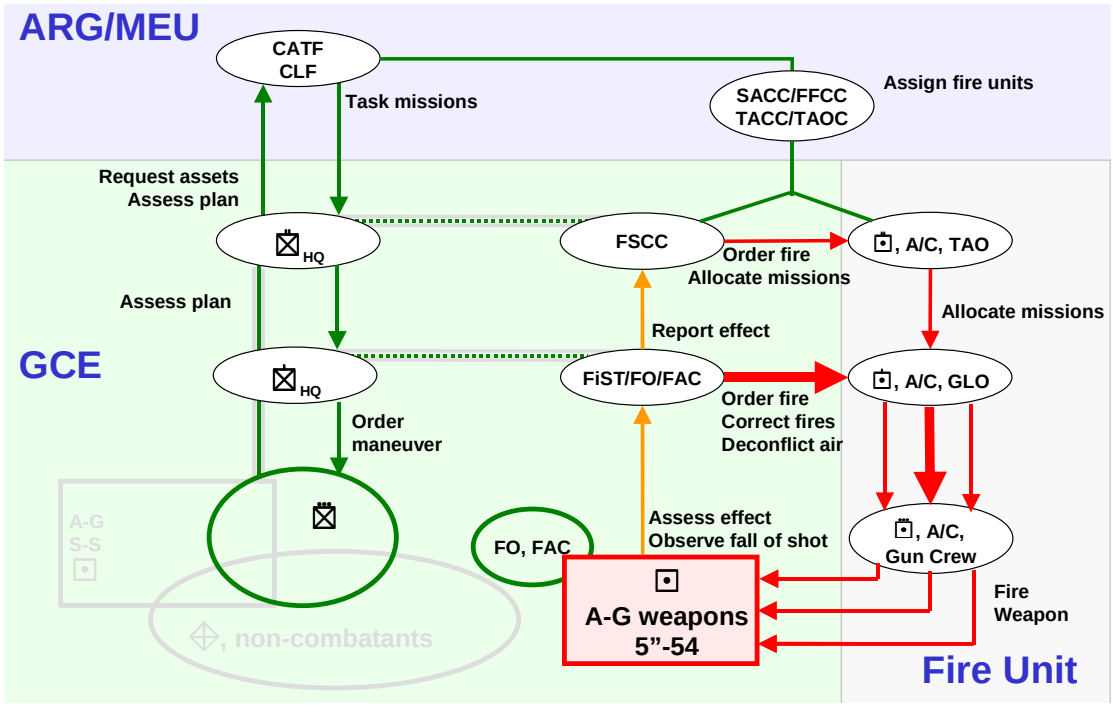


Figure 15. Amphibious training at Vieques



The effect of the training environment on the quality of the training

We systematically developed decision responsibility templates for every warfare area important to naval forces. We developed the templates for the actual combat environment and the current training environments for each warfare area. We used these training templates to capture how individuals, units, and forces are currently trained prior to deployment.

By looking across all of these templates, we found that we could group the training experienced today into five categories:

- Mobility and sensors
- Tactical maneuver
- weapon qualification using real fires
- Integration of tactical maneuver and real fires
- Force integration.

We used these groupings to identify the critical characteristics of the training ranges that exist for today's training methods. Finally, we explored some alternatives to current training ranges and methods by building decision responsibility templates for each of these alternative training environments. All of these templates are captured in [17].

Following are the results of this analysis.

The current training environments

We analyzed how the current training environment supports Navy and Marine Corps training requirements. This analysis focused on pre-deployment training for both Navy and Marine units. Our starting point for this analysis was the Navy Type Commander training instructions [18-21] and Marine Corps predeployment training orders. We also analyzed guidance supporting these instructions and orders, including the Fleet Exercise Publication [22-25], Marine Corps Combat Readiness and Evaluation System (MCCRES) [26], and Naval doctrine for amphibious supporting arms [27]. Using this

guidance we analyzed how the Navy and Marine Corps have used ranges to support pre-deployment training over the past ten years for unit- and force-level training.

To consider the current training environments, we built a matrix with the types of training considered for each warfare area. That matrix is illustrated in figure 16. We considered undersea warfare, surface warfare, air defense, air-to-ground strike, Amphibious Maneuver Warfare (AMW), and ground combat. Each warfare area requires the ability to first train specific units to fundamentally operate and employ their sensor systems. Once the individual units have been trained in the basics, they need to learn how to maneuver tactically. Next, they learn how to employ their weapon systems using real fires. Finally, the tactical maneuver is combined with real fires and ultimately, the training focuses on overall force integration.For current training we analyzed amphibious, vice expeditionary, maneuver warfare, has AMW is the focus of recent vieques training, Our analysis of future training environments analyzed expeditionary maneuver warfare.

Examples of real fire training include real missile firings against drones (MISSILEXs)[20] and qualifying naval gunfire in an amphibious mission (FIREX)[E]. Examples of tactical maneuver and fire include submarine versus submarine tactics and exercise torpedo firings conducted during Prospective Commanding Officer (PCO) training, strike warfare training during the airwing's Fallon detachment, and MEU combined arms training at Twenty-nine Palms. Force-level training includes the Joint Task Force Exercise (JTFEX) serving as the graduation exercise for the battle group and amphibious ready group.

The color scheme in figure 16 is intended to be that of a "stoplight" chart. Here "green" connotes that there are many ranges available for the type of training required for the warfare area and level of training. Yellow cells indicate that, although the ranges where this training can be conducted are not plentiful, there is more than one option. Red cells indicate cases where a single range is available for the necessary training. For ships, red cells indicate a single range is available on their coast. If that range were to become unavailable, the training represented by that cell of the matrix would be restricted. If the cell says N/A, it means that there is no training currently conducted for that warfare area at that level.

Figure 16. Current availability of training ranges

Platform / Warfare area	Mobility/sensor	Tactical Maneuver	Real Fires[1]	Tactical Maneuver and Real Fires[1]	Force integration
Sub-surface USW	Multiple undersea operating areas	Multiple undersea operating areas	Multiple undersea operating areas	Few instrumented USW ranges	Multiple undersea operating areas
Surface SUW	Multiple sea operating areas	Multiple sea operating areas	Multiple sea operating areas	N/A	Multiple sea operating areas
Air-Air AD/OCA	Multiple airspaces	Multiple controlled airspaces	Multiple controlled airspaces	N/A	Multiple airspaces
Air-Ground STK		Multiple overland airspaces	Multiple ground impact ranges	Fallon	Multiple airspaces
Amphibious AMW	Multiple sea and controlled shore sites	Few shore and controlled land sites	San Clemente Vieques	Vieques[2]	Camp Pendleton Vieques
GCE	Multiple controlled land sites	Multiple controlled land sites	Multiple ground impact ranges	29 Palms[3]	Multiple controlled land sites

1. Includes explosive and non-explosive (telemetry) weapons
2. Supports combined NSFS, Arty, CAS, and mortar training; limited maneuver and fires integration
3. Limited maneuver and fires at Camp Pendleton (Bn) and Camp Lejeune (Co)

From figure 16, it is clear that there are a few key ranges that support today's training environment: Fallon, San Clemente, Camp Pendleton, Twenty-nine Palms, and Vieques. The recent problems with access to the Vieques range and the associated consequences are clear from this chart. Currently, Vieques is the only range where tactical maneuver and real fires can be conducted with naval gunfire for AMW. Were DoN to lose Fallon or Twenty-nine Palms, the consequences would be just as serious or even more so. Therefore, we wanted to identify some actions the Secretary of the Navy could take today to mitigate the vulnerability of naval training to the ability to use a particular, unique range. We discuss these actions further below.

Figure 16 shows that AMW weapons training, unlike other warfare areas, is critically constrained with only one site on each coast

supporting land-impact naval gunfire training. West Coast trainers have mitigated this problem by qualifying ships in naval gunfire on a sea-impact acoustic scoring range.

East Coast trainers have purchased a Virtual At-Sea Trainer, Deployable Prototype (VAST DP) to increase the flexibility of their training. This system supports live gunfire precision training, and Amphibious Naval Surface Fire Support mission qualification. The system meets the formal requirements for qualifying the Ship's Combat Information Center and gun crews, but does not provide training for the naval gunfire spotters or the Fire Support Team, who coordinate tactical maneuver and fire. Furthermore, our analysis showed that the naval gunfire forward observer needs to observe the outcome of real fires, whereas for non-direct fire missions, the ship does not. This difference means that the ship can train using at-sea impact ranges, but the forward observers must train observing the location of impacts.

Figure 17 shows the implications of VAST DP on the training environment. VAST DP eliminates one of the red boxes from figure 16: real fires for AMW training. In figure 17 this cell is now green, indicating that real fires naval gunfire training can be conducted at sea in many locations. However, VAST DP does not support coordination of maneuver and real fires, so, absent Vieques, Camp Lejeune is the only land-impact range supporting coordination of Navy fires and land maneuver. Thus, the amphibious fire and maneuver cell is still red.

Figure 17 also shows the effects of losing access to Puerto Rican ranges. These ranges, administered by Atlantic Fleet Weapons Training Facility (AFWTF), include Vieques inner range, St. Croix underwater range, and an air defense range. The exact composition of AFWTF is described in more detail later.

Figure 17. Training range availability without AFWTF and with at-sea naval gunfire scoring

Platform / Warfare area	Mobility/sensor	Tactical Maneuver	Real Fires[1]	Tactical Maneuver and Real Fires[1]	Force integration
Sub-surface USW	Multiple undersea operating areas	Multiple undersea operating areas	Multiple undersea operating areas	AUTEC	Multiple undersea operating areas
Surface SUW	Multiple sea operating areas	Multiple sea operating areas	Multiple sea operating areas	N/A	Multiple sea operating areas
Air-Air AD/OCA	Multiple airspaces	Multiple controlled airspaces	Multiple controlled airspaces	N/A	Multiple airspaces
Air-Ground STK		Multiple overland airspaces	Multiple ground impact ranges	Fallon	Multiple airspaces
Amphibious AMW	Multiple sea and controlled shore sites	Few shore and controlled land sites	San Clemente VAST	Camp Lejeune[2]	Camp Pendleton Camp Lejeune[2]
GCE	Multiple controlled land sites	Multiple controlled land sites	Multiple ground impact ranges	29 Palms[3]	Multiple controlled land sites

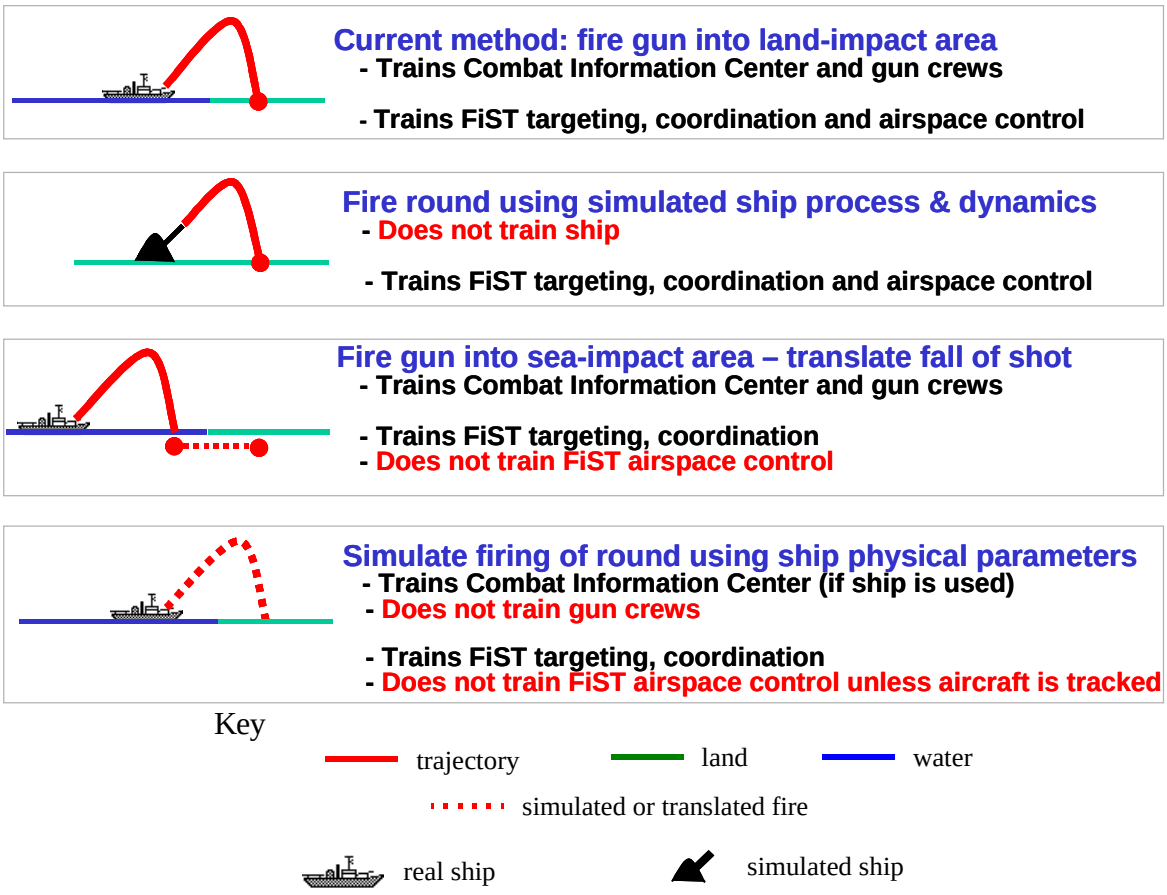
1. Includes explosive and non-explosive (telemetry) weapons
2. Supports Arty, CAS, and mortar training; could support limited naval gunfire using FIREX qualified ships
3. Limited maneuver and fires at Camp Pendleton (Bn) and Camp Lejeune (Co)

From the figure it is clear that if the St. Croix underwater training range is closed in conjunction with leaving Vieques, the Atlantic Undersea Test and Evaluation Center (AUTEC) would be the only East Coast underwater facility supporting tactical maneuver and fire. The red cell in figure 17 reflects this critical problem for Undersea Warfare. Additionally, AUTEC is not located in a U.S. territory, potentially increasing the risk of continued access to the range. The development of an additional East Coast underwater range and deployable underwater tracking ranges would reduce this single-point failure, as well as giving ASW forces the capability to train overseas with a variety of opposing nations and in a range of undersea conditions.

We looked at how using simulated naval surface fire support affects combined arms training. Figure 18 illustrates different methods of simulating NSFS. The top box in the figure shows how the Navy currently trains with real NSFS fires. The ship shoots into a displaced

land-impact area with aimpoints simulating targets important to maneuvering forces. Unlike the gunfire qualification exercise (FIREX) the Fire Support Team, including forward observers, are the principal training audience, with the ship getting some training while providing training support.

Figure 18. Different methods for simulating NSFS in amphibious training



The training objectives for the FiST and FOs are observing and correcting the fall of shot, detecting and identifying systematic errors in the precision of fires, integrating naval fires into the combined arms, and airspace deconfliction for ground- and air-based fires. Figure 18 shows that the current method supports training for both the FiST and ship training. Substituting a gun ashore for the ship still provides

training for the FiST, but only if the character of errors from the simulated gun match the errors characteristic of a ship at sea. This includes navigation and ship dynamics errors. The matching of errors is critical for training FOs to detect and correct both individual round errors and systematic errors in firing solutions. *No current simulator meets these criteria.*

The third box in figure 18 shows that a ship can also be used with sea-impact firing, with a translation of the fall of shot onto the target terrain. If the translation of shot is accurately modeled and physically observed, the ship and the FiST receive training. The current funded program to provide this type of training is VAST DP. VAST DP assumes a two-dimensional terrain. To accurately map the fall of the shot into the exercise environment, a three-dimensional terrain overlay will have to be added. Three-dimensional terrain overlays are an important component of a current program, which is designed to be added to VAST. This combination could provide the necessary training environment for the forward observer and ship.

Because the round does not go through the target airspace this method cannot train airspace coordination. This method requires that the forward observer detect the simulated fall of shot, either by a visual signal near the simulated impact point, or virtual projection in a visual sighting device.

Finally, the last box in figure 18 illustrates a method for simulating the trajectory of the weapon. If a ship is used as the basis for this simulation, this method trains the FiST and ship's Combat Information Center; the ship's gun crew is not trained. This method requires an accurate simulation of the round, which, if a ship is used, requires instrumentation of the ship and gun sufficient to support prediction of the fall of shot consistent with the real gun. Like the displaced, sea-impact method, this method requires an accurate method of giving a visual cue to the FiST for detecting and correcting round and systematic errors. The ship can also be simulated, but again, the errors associated with the simulated fall of shot must match that of a real naval gun. Finally, this method can only train airspace deconfliction if the ship and aircraft are tracked in a common frame of reference. The strength of this method is that it can be deployed, does not require

permission to fire weapons, and supports force-on-force training. The price of this flexibility is a lack of emotional conditioning for the training audience.

Our analysis showed that a combination of simulation methods is required to duplicate the training supported by land-impact, sea-based naval gunfire. For example, combining sea-impact naval gunfire with land-based, land-impact naval gunfire simulators trains ship CIC and gun crews, forward observers, and sea- and land-based fires coordinators (e.g., FiST, SACC). Such capability does not currently exist but we recommend that it be developed.

Figure 19 illustrates the impact of this change to simulation. From figure 19 it is clear that no aspect of amphibious training would be red or vulnerable to single-point failures as is the case today. By also introducing mobile underwater ranges, the vulnerability of USW training to the loss of AUTEC is eliminated. Figure 19 also shows that DoN must make every effort to protect Fallon and Twenty-nine Palms as they are vital for strike and ground combat training and the alternatives we considered were not adequate to provide the key decision responsibilities for these warfare areas.

The training environment and the quality of training: Summary

In this section we have shown how each warfare area has different lethal responsibilities and key decision points that require specific training. We have shown that, to train these responsibilities, real fires are sometimes required, but have also shown that not every warfare area depends on the use of real fires for its maneuver-fire and force integration training. We have shown that there are few ranges where use of live fire is possible using methods that support the training requirements. Furthermore, the use of live fire introduces several *single-point failures*, such as the Vieques range today. There are several steps the DoN can take to reduce their vulnerability to single-point failures in range availability.

Figure 19. Range availability with simulated NSFS and mobile underwater ranges

Platform / Warfare area	Mobility/sensor	Tactical Maneuver	Real Fires[1]	Tactical Maneuver and Real Fires[1]	Force integration
Sub-surface USW	Multiple undersea operating areas	Multiple undersea operating areas	Multiple undersea operating areas	Multiple undersea operating areas	Multiple undersea operating areas
Surface SUW	Multiple sea operating areas	Multiple sea operating areas	Multiple sea operating areas	N/A	Multiple sea operating areas
Air-Air AD/OCA	Multiple airspaces	Multiple controlled airspaces	Multiple controlled airspaces	N/A	Multiple airspaces
Air-Ground STK		Multiple overland airspaces	Multiple ground impact ranges	Fallon	Multiple airspaces
Amphibious AMW	Multiple sea and controlled shore sites	Few shore and controlled land sites	San Clemente VAST	Multiple ground impact ranges	Few shore and controlled land sites
GCE	Multiple controlled land sites	Multiple controlled land sites	Multiple ground impact ranges	29 Palms[2]	Multiple controlled land sites

1. Includes explosive and non-explosive (telemetry) weapons
2. Limited maneuver and fires at Camp Pendleton (Bn) and Camp Lejeune (Co)

First, the Navy can develop sea-impact scoring ranges (VAST) to qualify ships in naval gunfire. VAST will give the crews experience in handling explosive munitions and feedback regarding the precision of their fires. In the long-term, DoN should develop an ability to use simulated NSFS to support combined arms training in EMW. Although real fires are preferred because they provide lethal responsibility training for the FiST and forward observers, amphibious maneuver training can be accomplished with effective NSFS simulation. The first step in this initiative is to develop the ability to accurately instrument gunfire trajectories and tracking. Ultimately, the simulation would allow the development of displaced NSFS ranges that are linked to artillery actions for fires. To provide effective training, however, the development of these ranges must be tested with the support of MEU commanders to ensure that the simulations are adequate to assess NSFS combined arms proficiency.

Finally, Fallon and Twenty-nine Palms remain single-point failures and our analysis did not point to any possible substitutes for the training conducted at these ranges. We did, however, consider similar ranges in use by other services [17]. By integrating the instrumentation and use of similar ranges by multiple services, all services will benefit from the reduced risk of losing one of their key training ranges.

Future training environments

As part of meeting with key operational and training commands, the Senior Study Group considered requirements for the future that might result in a need for different training methods or environments. The group's chacterization of naval operations included such terms as mobility, network centricity, lethality, and shock. The group agreed that such operations would be joint and would require the delivery of integrated, coordinated fires from a variety of platforms. In addition, there would be a need to counter asymmetric threats. Friendly forces would be widely dispersed but highly networked, with the ability to maintain greater situation awareness than they have today. Long-range precision weapons would be the norm and would require different training facilities than exist today. The Study Group noted that precision weapon systems tend to be expensive and that DoN might not be able to afford to fire a large number of such rounds in training. The group also noted that DoN would not be able to afford separate infrastructures to test and train in Network Centric Operations.

The group noted that training facilities would have to evolve along with warfighting concepts and tactics, techniques, and procedures. They viewed technology as being a cornerstone of future approaches to training. For example, networked training with "reachback" capability would allow access to schoolhouses and subject matter experts. The group considered scenarios in which widely distributed forces with a common operational picture could orchestrate deep strikes using live ordnance in one location in support of an actual amphibious assault in an entirely different location. All events would occur in highly instrumented ranges for which feedback, either real or near-real time, would be provided to measure participants' performance.

Although the group considered a variety of technology-based approaches to training, they cautioned that such approaches would not be able to replicate the stresses associated with fire events. They

also noted that, although many factors could result in reducing the requirements for live training, deploying units would still need to demonstrate competence in the delivery of live fire.

Our approach to address the issue of future training environments to support DoN's needs was to analyze how training facilities needed to evolve with the concepts, tactics, and procedures being developed. We looked at the operational concepts for the future that are being developed by the Navy and Marine Corps as well as their planned investments. The concepts we considered included: Joint Vision 2020, the Navy Strategic Planning Guidance, Expeditionary Maneuver Warfare concept, Marine Corps Warfighting Concepts for the 21st Century, operational maneuver from the sea (OMFTS), and Naval Surface Fire Support Concept of Employment (version 3). To understand the planned investments for future systems and capabilities, we considered the Acquisition Categories Matrix (ACAT), the Pre-Major Defense Acquisition Program (MDAP), Operational Requirements Documents (ORDs), and Missions Needs Statements (MNS). All of these documents and the analysis of future training environments are discussed in [8].

By reviewing the current and envisioned concepts of operations and comparing them with the investment strategies, we found that the majority, or about 60 percent, of the investments are aimed at supporting current concepts. The following future concepts are supported by investments:

- Common operational picture (COP)
- Ship to objective maneuver (STOM)
- Operational maneuver from the sea (OMFTS)
- Linked sensor to shooter
- Network-centric warfare.
- Global information grid.

The Navy and Marine Corps both support these concepts, but with slightly different emphasis.

The Navy is focused on employing information technology to gain the intelligence and command and control to support the use of long-range weapons for land attack. This concept emphasizes the employment of long-range, high-altitude, guided weapons. The training environment for the use of these weapons will require access to large exclusive-use airspace. To train to the employment of sea-based land-attack weapons such as the extended range guided munition (ERGM) with live fire, large, contiguous airspace above land and sea would be required.

The Marine Corps envisions advancements in information technology to aid in its ability to conduct maneuver and fires. Expeditionary maneuver warfare, which combines the concepts of OMFTS and STOM, envisions widely dispersed forces and headquarters. Due to the dispersed nature of the concept, the training environment will have to support tactical movements to and through a variety of operations areas, including sea lanes. It will also require the ability to have information connectivity between the dispersed forces.

Training for new concepts

These new concepts discussed above will require some changes to the way naval forces train and use the training ranges.

Although most funded future weapon systems can be trained using current weapons training methods, new systems such as the extended range guided munition (ERGM), cannot be trained in the same way that naval gunfire is currently trained. As mentioned above, ERGM employment will require large, contiguous airspace above land and sea. This will be very difficult to support with real fires on training ranges. It may be more likely that ERGM can be trained much the same way that we currently train for the use of the Tomahawk land-attack missile (TLAM). Ship crews are trained to employ TLAM through all steps up to launching the missile. Once the missile is launched, the crew has no ability to affect its flight path or impact. For ERGM, crews may be able to undergo simulated training based on engineering-level test fires of the system. This training may include forward observer corrections made to simulated ERGM fires. Because ERGM will be more like TLAM than traditional naval gunfire, this

simulated training should be capable of supporting the training requirements.

To train for expeditionary maneuver warfare, the physical space within current ranges should be sufficient to support the necessary training. Many of these ranges are not contiguous, and transit between ranges requires passing through dual military/civilian use areas, e.g., sea lanes. Therefore, to achieve the dispersion called for by this concept, the training would have to at least include administrative maneuver between existing company-size maneuver ranges. If the scenario includes threats to elements maneuvering between objective areas, the training environment must include options for the maneuver element to respond tactically to the threat. Typically this can be accomplished by including several areas of controlled airspace along the route connecting the objective areas.

However, current East Coast ranges do not support the information requirements for dispersed training. Most of the future warfare systems are not sufficiently developed to make specific recommendations concerning information support requirements, but the following guidelines should help develop the required support for specific candidate sensor, weapon, or command and control systems. For example, if the individual ranges are too small to contain both sensor and shooter, the environment must support the exchange of sensor and weapon information between the ranges. For training on dispersed ranges whose separation precludes exchange of required tactical information, the range infrastructure must support relay of relevant information. Finally, if tactical systems do not provide sufficient information to support an assessment of training, the range instrumentation and inter-range infrastructure must support the collection and exchange of relevant information.

Given the service ownership and geographic distribution of East Coast ranges, this implies better coordination among the services to ensure that range instrumentation and range use is adequate to support training for the dispersed tactical concepts of the future.

Where does this lead?

We have compared the combat operational environment with the various training environments. We have introduced the concepts of emotional conditioning and lethal responsibilities. We have examined the key decisions in each of the naval warfare areas and identified those decisions that are associated with lethal responsibilities. We have also looked at current training environments, and some alternatives and we have attempted to predict the training environments that will be necessary to support future operational concepts and weapon systems.

In this section, we will tie all of these pieces together and summarize our key findings with regard to the use of real fires, current training ranges and methods, the role of instrumentation and simulation, and future training environments. Finally, we will draw together the implications for the loss of the Vieques training range.

Real fires training - the need for fires training

Real fires training includes the use of explosive, inert, and telemetry fire training. Our analysis showed that real fires training is critical for weapons qualification training for all weapons and platforms. Although the methods differ by weapon, all weapons have some ranges where they are employed. We also showed that real fires training was critical to support fire-maneuver and force-level amphibious operations training.

For strike warfare, we noted that the focus and feedback associated with real fire training was more important than the timing of the training within the IDTC or the degree of tactical realism associated with the fires. By automating tracking and scoring for all weapons and coupling this with intensive weapons tape analyses for all drops, it might be possible to extend the SFARP-like training value to other real fire opportunities.

For all live fire, however, explosive confirmation provides little technical feedback. For example, simple observation of ordnance detonation, or lack of detonation, does not provide miss distance information or reasons for failure. This fact has been recognized by some training communities. Most surface-to-air and air-to-air missile shots are made with telemetry rounds. These rounds provide more detailed information about the engagement, and hence, better feedback to both engineering and operational audiences. Training could be enhanced if the feedback for all live fire events was improved. By adding tracking and telemetry, it would be possible to assess why a weapon failed. This would include assessment of processes such as weapons assembly and loading at sea. Adding tracking and telemetry would also help improve the accuracy of no-drop simulations.

Training ranges and methods - warfare area requirements

Using the decision responsibility templates, we examined every warfare area to identify the critical aspects of the training for that area and the kind of range support and training methods necessary to achieve that training. We found that multiple ranges exist to support mobility and sensor training, tactical maneuver training, and weapons qualification training for all warfare areas. But even with the introduction of simulation and mobile at-sea ranges, we found that Fallon and Twenty-Nine Palms are critical ranges with no current Department of Navy alternatives. These ranges are then "single-point failures" for training and should be protected. To guard against the potential loss of these ranges, even with careful attention and protection, the DoN could establish relationships and shared instrumentation with comparable ranges owned by other services. Such relationships would help mitigate the vulnerability to single-point failures for all services.

Finally, we found that the methods of training the combination of maneuver with fires are different across the naval warfare areas. For example, surface warfare and fleet air defense use only constructive fires in their maneuver-fire training. For air-to-air, all fires are simulated. For strike, ground, amphibious, and sub-surface warfare, real fires are emphasized and used.

From our analysis of the decision responsibility templates, it is not clear that these are necessarily the best training methods for each of these warfare areas. For example, we found that maneuver-fire training for strike warfare is not dependent on the use of live fire to train a carrier battle group in the key decisions and lethal responsibilities associated with this warfare area. Current training for amphibious and ground warfare, however, requires real fires to support the maneuver-fire training events. For subsurface, due to the difficulties of modeling the acoustic environment, the community has developed safe ways of employing weapons equipped with telemetry warheads to support their conduct of maneuver-fire training.

The role of instrumentation and simulation

We already discussed the importance of improving instrumentation support for real fire weapons employment to enhance the value of real fires weapons qualifications training. We also identified areas where simulator support could become very valuable for maneuver-fire training.

For amphibious maneuver-fire training, we examined how the decision responsibility template would change with the introduction of simulators and the elimination of real fires. Although the template with simulation does not replicate the key lethal responsibilities as well as with real fires, our analysis showed that simulator-supported training could be valuable as discussed below.

Simulators currently support staff combined arms training where both the maneuver and the fires are simulated. These simulators allow the training audience to employ their decisions and observe the outcomes prior to participating in the live fire exercise. However, when the same decisions are made in the live fire exercise, analysis of exercise safety revealed that the training audience makes errors in coordinating fires and maneuver which, if unchecked, would have lethal consequences.

Clearly, a different kind of simulator would have to be developed to adequately support maneuver-fire exercises. Simulators that accurately represent weapon trajectories could still support real

maneuvers and form a bridge between current staff and real fire training. If the simulator development included naval gunfire and the simulators are mobile, this could increase the number of locations suitable for maneuver-fire training of amphibious and ground forces. These locations could be throughout the United States and overseas. Rigorous validation of these simulators would be required to ensure that these simulators adequately support the assessment of combined arms coordination and to build the trainer's confidence in these simulators.

While simulators and simulations will likely increase the flexibility for future training environments, it is important to remember that simulations do not produce the same physiological responses to lethal stress as real fires. Research shows that performance is lower in real, stressful conditions compared to simulator performance of the same task. Real performance is lower for physical, cognitive, planning, decision, and group skills. We expect that the same will be true for combat performance relative to simulator performance. The research also indicates that the difference between simulator and real performance decreases with increasing individual experience.

Finally, emotional conditioning is not possible through the use of simulators. Therefore, while simulators can increase training flexibility, simulators cannot completely replace training with real fires.

Future training environments - need for distributed training

Our analysis of the future systems currently envisioned by DoN showed that current weapons training methods will support the training of most future systems. There are exceptions, however. The Extended Range Guided Munition (ERGM) cannot be trained as naval gunfire is trained. Although, like gunfire, ERGM will be fired from a ship, it will be more like TLAM than a gun. ERGM will be GPS-guided, long range, and focused on land attack. Because of this, its training should resemble TLAM training, using simulated fires based on engineering test fires. The difference between ERGM and TLAM is that ERGM may be employed with the option of forward observer corrections, an aspect that must be included in the training environment.

With regard to concepts, Expeditionary Maneuver Warfare is the concept that could have the most significant requirements for future training environments. Because EMW calls for maneuver over large areas with forces operating together across great distances coordinated through the use of information technology, the demands for contiguous air, sea, and land space could be significant. Our analysis suggests, however, that EMW could be trained using current physical ranges that are netted together, allowing for the exchange of sensor and weapon information across ranges. The forces would have to administratively maneuver between ranges, but, once in place, the complex coordination required for EMW could be trained. The simultaneous use of multiple ranges will require improved interservice range coordination, which will have to become a DoN priority in order to create this future training environment.

Implications of the loss of Vieques

Vieques

What do we mean when we refer to Vieques? Vieques is part of the Atlantic Fleet Weapons Training Facility (AFWTF). Vieques Island is the inner range of this facility. This inner range supports air-to-ground training on the land and sea-impact target range, naval surface fire support, supporting arms (including artillery, mortars, armor, and small arms), and aerial mining. The inner range also has the sea and beach maneuver areas that support amphibious landings and helicopter landing zone operations. This is the range that is scheduled to close in May 2003.

AFWTF also has an outer range that consists of two off-shore areas northeast and southeast of Puerto Rico. These areas are open-water tracking and telemetry ranges. They are used for weapons firing against airborne and surface targets and for the control of surface and airborne target drones.

The third part of AFWTF is the underwater tracking range that is north of St. Croix. This area is a large, deep-water acoustic tracking range. It supports weapons and tactics development and training for

air, surface, and subsurface undersea warfare. It also supports weapons and sensor evaluation and measurements of ship-radiated noise.

Finally, the electronic warfare range extends over Puerto Rico, Vieques Island, and St. Croix. This range includes integrated, multi-axis, multiband electronic warfare simulator and sensors. It supports both fleet electronic warfare training and electronic warfare systems testing and evaluation.

Vieques unique training

Currently, Vieques is the only East Coast land-impact range used to support four critical training functions:

- Qualification of ships in naval gunfire
- Training forward observers in spotting and correcting naval gunfire
- Training fire support teams to integrate naval gunfire in amphibious combined-arms training
- Assessing Navy and Marine staff planning and execution of force-level littoral maneuvers and force fires, including naval gunfire.

Vieques uniquely supports the last function; there is no comparable capability on the West Coast of the United States.

We found that simulators currently support these functions during initial training; however, no existing simulator, or set of simulators, adequately supports final qualification or assessment of the training for these functions.

We found that West Coast trainers have access to facilities supporting the first three functions. West Coast trainers use land-impact artillery fire to simulate naval gunfire in the fourth function, the assessment of amphibious force fires and maneuver. East Coast trainers could use the same approach for training this function.

Alternatives for qualification of ships in naval gunfire

The introduction of at-sea NSFS scoring through the VAST system will allow ships to qualify in naval fire at sea, which would substitute for the Navy's dependence on Vieques for this function. VAST DP will be delivered in Fall 2002. Once introduced, this system will improve feedback to the ship on precision of fires. However, it will be important to continue the development of the system. These improvements include virtual terrain overlays through the VAST system to improve the tactical fidelity that VAST DP can provide ships when training naval gunfire, permitting assessment of defilade fire and correcting fires over hilly terrain. To assess all current FIREX missions, some method to assess air-burst and illumination rounds must also be included.

Alternatives for training forward observers in spotting and correcting naval gunfire

The only existing East Coast range that could be used to train the forward observer with real naval gunfire is Camp Lejeune. Given the small size of the Camp Lejeune impact area and the proximity of personnel on base, only qualified ships should be used to support training of the forward observers. To accommodate these constraints, the naval gunfire will have to be controlled to reduce the likelihood of skipped rounds. Additionally, the intercoastal waterway will have to be closed during periods when naval guns are fired.

East Coast forward observer training could also be accomplished with real naval gunfire at San Clemente Island. These forward observers would train with West Coast ships; however, there is currently no formal requirement to train forward observers with deploying ships as a team. This method would incur additional TAD costs.

Future forward observer training with real naval gunfire could also be supported by the development of new ranges. The only viable option this analysis identified in the United States) there are other possible sites in the Caribbean) is the Texas Kenedy Ranch. This area is sufficiently large and separate from populated areas to support realistic, tactical naval gunfire. Its development would require permission to support sea-based, land-impact naval fires. These permissions will

likely be very difficult to obtain due to community and environmental concerns [7]. To support forward observer training, naval gunfire trajectories would have to pass over the Padre Island National Seashore as well as the intercoastal waterway. Without these permissions, the value of developing this range is not clear.

If the ability to use land-impact, sea-based naval guns is not available, our analysis suggests that it will be possible to use simulated naval gunfire to train forward observers. To be an effective training mechanism, it is essential that the simulators produce the same distribution of errors as a real naval gun would when fired from sea. No simulator meeting these requirements currently exists. The Navy and Marine Corps would need to develop and validate new simulators for this training. This is a long-term issue; no simulator meeting these requirements will exist in 2003.

Alternatives for training fire support teams to integrate naval gunfire in Expeditionary Maneuver Warfare combined-arms training

Alternatives for training FiSTs are very similar to those that exist for training forward observers. For FiSTs, there is an additional requirement, however. FiSTs must integrate multiple sources of Expeditionary Maneuver Warfare (EMW) fires, including mortars, artillery, close air support, and naval gunfire. Camp Lejeune currently supports training of the integration of all of these fires except naval gunfire. If naval gunfire can be added to support the training of forward observers, FiSTs can also be trained at Camp Lejeune.

The combination of the constraints on naval gunfire discussed above, with the restrictions on the use of airspace at Camp Lejeune, make this FiST training environment somewhat more constrained than what is currently available at Vieques. The small size and proximity of populated base facilities will restrict the geometry and flexibility of training and assessment scenarios. Additionally, these constraints mean that there is little margin of error in the execution of live fire training. This will result in tighter control of live training events, which will in turn reduce the ability to train and assess the trainee's

response to unanticipated scenario events, or to correct normal execution errors.

Nevertheless, we also found that Camp Lejeune's live-impact range will support the assessment of critical integrated combined arms tasks such as timing coordination of dissimilar fires, targeting accuracy, and airspace deconfliction. Training of these tasks is essential for integrating fires, the prime responsibility of the FiST.

San Clemente Island is also an option for training East Coast FiSTs. West Coast FiSTs are currently trained at San Clemente Island and, as for forward observers, East Coast FiSTs could be deployed to San Clemente Island for Temporary Additional Duty.

Naval gunfire simulators that support forward observer training will also support FiST training if the simulator can be integrated with other types of fires and firing platforms. When developing naval gunfire simulators, this integration requirement should be included.

Finally, the Texas Kenedy Ranch is large enough to fully support FiST training, assuming the access and environmental concerns could be addressed.

Alternatives for assessing Navy and Marine Corps staff planning and execution of EMW force fires including naval gunfire

Navy and Marine Corps staff planning for EMW force fires is at the force level of training for Expeditionary Maneuver Warfare. At the force level, we are really considering the training environment necessary to support EMW operations. At this level, the FiST, with the forward observer, is part of a larger training audience that focuses on the ability to transition the command of forces from sea to shore.

Camp Lejeune currently supports all elements of this training environment with the exception of naval gunfire. Our analysis showed that, at the force level, simulated vice real naval gunfire is sufficient to support force-level EMW training. Real naval gunfire, although desirable, is not a requirement. At Camp Lejeune, the addition of either real or simulated naval gunfire would be necessary to support

force level training. The West Coast currently uses a version of the simulated gunfire alternative.

With regard to the development of new ranges, the permissions to support the transition of forces ashore would be necessary at the Texas Kenedy Ranch to support EMW force-level training. Specifically, permission to cross through the Padre Island National Seashore would be required.

The impact of the loss of Vieques

In summary, Vieques now uniquely supports East Coast training of four functions: naval surface fire support, forward observers, FiSTs, and force-level Expeditionary Maneuver Warfare. When the Vieques range closes, it will be necessary to train these missions elsewhere. The deployment of VAST DP will enable the Navy to qualify naval surface fire support ships without Vieques. The training of forward observers, FiSTs, and related personnel can be accomplished immediately by providing their training at San Clemente Island, CA., along with West Coast forces. An alternative to using San Clemente, or an addition to it, would be to allow real naval gunfire into Camp Lejeune, NC, for the relatively few days in the year when such training is needed. Although this has practical limitations because of the size of the Lejeune G10 range, it would facilitate training in all four functions. Simulating naval gunfire with artillery weapons at Camp Lejeune, as is done now at Twenty-Nine Palms, CA, is also a possibility.

For the longer term, developing a new naval gunfire simulator is highly desirable, and we are recommending that R&D investments be made to accomplish this. The simulator must be of sufficient fidelity to support the training of maneuver warfare fires control. No simulator exists that meets these requirements, nor is there yet a statement of operational requirements for such a simulator. Writing such a statement is the beginning point of creating an R&D program. We are also recommending the addition of new instrumentation on existing ranges to improve training.

Also for the longer term, it might be feasible to develop a new naval gunfire and maneuver warfare range, although this would undoubtedly be costly. As described in this report, there appears to be one

area in Texas suitable for such a range. There are also islands in the Caribbean that might be suitable, some of which we discussed in an earlier CNA analysis [10]. Of course, benefits against the likely costs of any particular range option would need to be evaluated.

Training Resources Strategy

CINCLANTFLT has developed plans to improve existing East Coast ranges [2] over the next seven years. If fully implemented, these multisite, multidimensional improvements, combined with specific improvements in range instrumentation and training simulations, will result in a set of netted independent ranges supporting a training environment that exceeds the capability of the AFWTF ranges for all Navy warfare areas. Within limits, this program reduces the consequences of losing any one range as the training objectives could still be met through the use of the remaining netted ranges. According to CINCLANTFLT, to achieve this potential, the Training Resources Strategy (TRS) will require full funding for the next seven years.

We analyzed the ability of the TRS to support current fleet training requirements. Specifically, we looked at the ability of the TRS to support current TYCOM pre-deployment guidance and COMSECONDFLEET intermediate and advanced training exercises, Composite Unit Training Exercise (COMTUEX), and Joint Task Force Exercise (JTFEX). We found that the TRS supports all current training requirements, and if funded and executed as planned, will enhance the quality, flexibility, and capacity of the Navy's East Coast training capability. Additionally, we found that the planned training environment resulting from this seven-year development program will be a significant improvement over the current training environment, including the AFWTF facilities. These improvements focus on areas our warfare analysis showed to most need improvement: instrumentation, simulation, varied target complexes, and threat presentations, including high-fidelity targets.

Recommendations

We suggest that the Secretary of the Navy pursue the following recommendations to ensure that naval forces will be trained for real-world operations:

- Continue to develop multiple, independent training environments to improve surge capability, improve flexibility, and reduce the effects of restrictions or loss of particular training ranges.
- Implement the Training Resources Strategy. This strategy will take the Navy to a distributed, capable network of independent ranges on the East Coast that will meet current and future training requirements.
  - In the interim, continue support and use of the AFWTF outer range and the underwater range.
- Implement EMW alternatives.
  - Ensure VAST DP remains on schedule and is capable of qualifying ships for naval gunfire using at-sea acoustic impact scoring and that it can assess air-burst and illumination missions. Continue to develop virtual terrain overlays to improve the tactical fidelity of the system.
  - Use Camp Lejeune for real fire naval gunfire to support naval combined arms training. Only FIREX-qualified ships will be able to use this range due to safety limitations. Practically, this means training for forward observers but not FiST.
  - Use San Clemente Island to train East Coast FiST/FSCC to integrate live naval fires.
  - Develop a naval gunfire simulator to support control and integration training for EMW fires.

- Improve range instrumentation and simulation. Instrumentation and simulation should be developed for all platforms and major weapon systems.
  - — Develop weapons-level and maneuver-fire instrumentation and simulation that can operate simultaneously with real fire for validation. Ensure trainers are willing to certify that the simulation supports training and assessment standards.
  - — Embed instrumentation and simulation in new systems.
- Support integration and coordination of training ranges. DoN should coordinate with other services to integrate selected CONUS ranges for distributed tactical and force training for the future.
- Conduct a vigorous community relations program to ensure continued use of critical ranges for live-fire training including Twenty-nine Palms, Fallon, and San Clemente Island. This program should be built on an understanding of how the critical training range requirements are related to the desires and concerns of the local community.
- Investigate the development of new ranges.
  - — The Texas Kenedy Ranch is an area that could be worth developing into a land-impact training range by DoD. It would be large enough to support combined arms coordination exercises. Its development would require permission to support sea-based, land-impact naval fires and tactical amphibious landings. These permissions will likely be very difficult to obtain due to community and environmental concerns and, without them, the value of developing this range is less clear.
  - — Consider development and use of privately owned ranges and ranges operated by other nations. These ranges have the potential to improve DoN's training environment and to serve as backups to U.S.-based ranges. Because of their vulnerability to decisions beyond our control, they should not be relied upon as the sole ranges for any training

function. Nevertheless, they may offer an alternative that could enhance DoN's overall training environment.

Appendix: Senior study group conclusions

To support the Vieques study, the Secretary of the Navy convened a senior study group of experts. The study group was chaired by Admiral Leighton Smith, U.S. Navy, retired, and General Charles Whilhelm, U.S. Marine Corps, retired. They were assisted by: General John Tilelli, U.S. Army, ret.; General Richard Hawley, U.S. Air Force, ret.; General Richard Hearny, U.S. Marine Corps, ret.; The Honorable Philip Coyle, former ASD for RDT&E; Ms. Sherrie Goodman, former DUSD for environmental security; VADM James Perkins, U.S. Navy, ret.

The study group chairs submitted the following conclusions at the end of their review of naval training [29]:

- Current naval forces training methodologies, the inter-deployment training cycle (IDTC) and pre-deployment training program (PTP), that build incrementally upon individual and unit capabilities are sound.
- Nothing in other service training philosophies suggests a need for naval forces to change their fundamental approaches to training.
- Determining how to meet naval training requirements involves considering the appropriate type of training (live, constructive, virtual) as a function of a given level of training (individual, unit, joint).
- Warfighters must be exposed to three broad categories of stressors:

  a. Handling live ordnance

  b. Delivering live ordnance in the proximity of troops, and

  c. Physical exposure to the effects and delivery of live ordnance.

- The fundamental concept whereby the CVBG and MAGTF integrate and orchestrate their combat power in the four dimensions of land, surface, air and subsurface, is not adequately supported by today's training and readiness environment.
- It is essential for naval forces to have access to a live-fire training environment that allows for the simultaneous, live-fire, integration of mortars, artillery, naval surface fire support (NSFS), and close air support (CAS).
- With access to Vieques facilities, training opportunities for east coast forces are superior to those available to west coast forces.If access to Vieques is terminated without suitable alternatives and or enhancements, the advantage will shift to the west coast.
- Future naval forces will operate as smaller, widely distributed units conducting nonlinear operations in frequently noncontiguous battle space, and the JV2020 tenets of dominant maneuver and precision engagement will generate increased emphasis on the integration of fires and maneuver.
- Historic trends to discount readiness requirements when training opportunities are constrained by transient economic and local political factors must be reversed. Concurrently, recent trends to provide appropriate levels of funding in support of new training initiatives must continue.
- The current training and readiness environment will not be capable of supporting new weapons and C4ISR systems already in development, and will not meet the longer range challenges of JV2020.
- Virtual training and simulation will serve an increasingly important purpose in the training continuum, but cannot replace live fire.
- Collaboration between the DON and US Joint Forces Command on initiatives such at the Joint National Training Capability may provide economical and efficient means to achieve shared training and readiness objectives.

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